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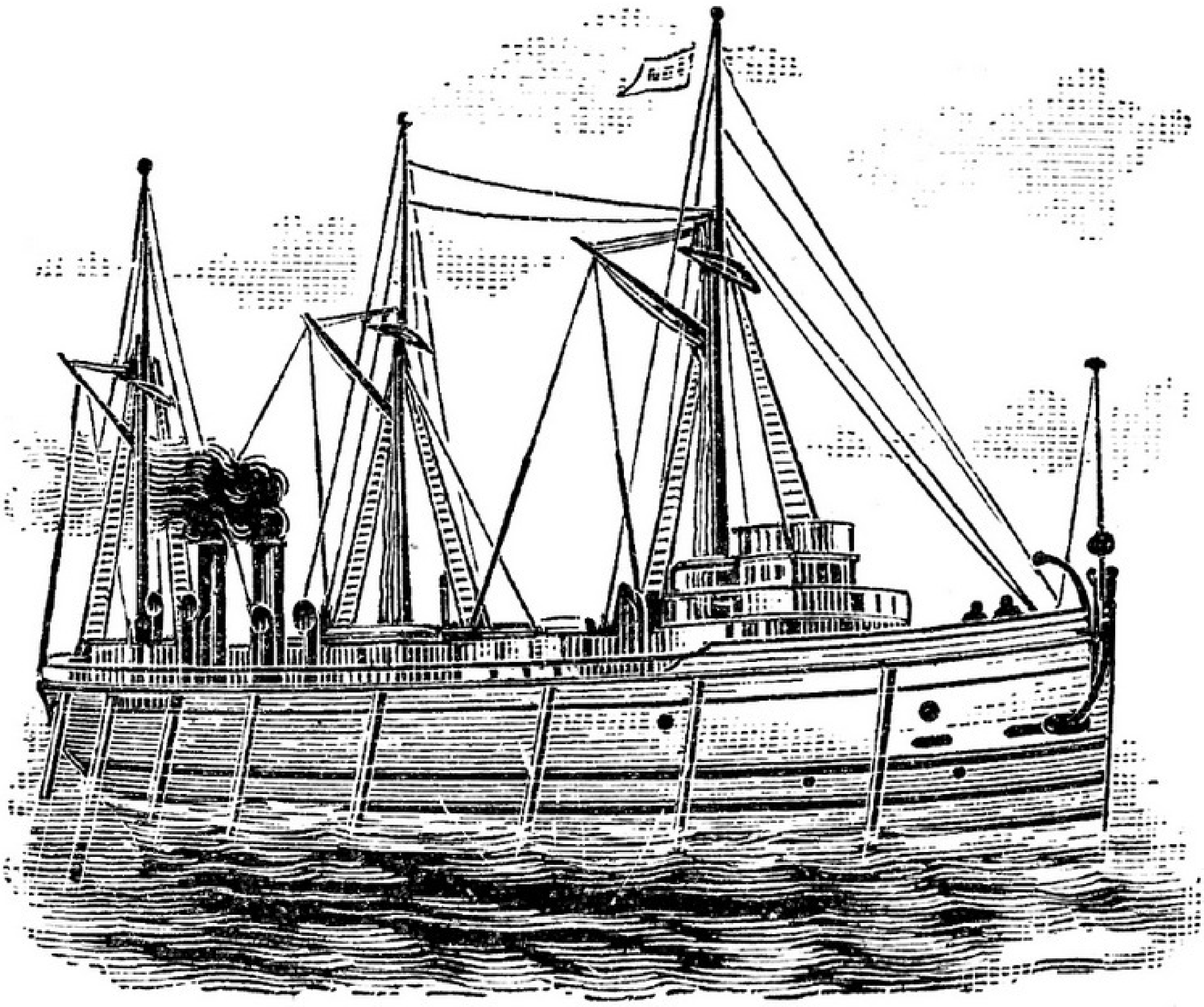

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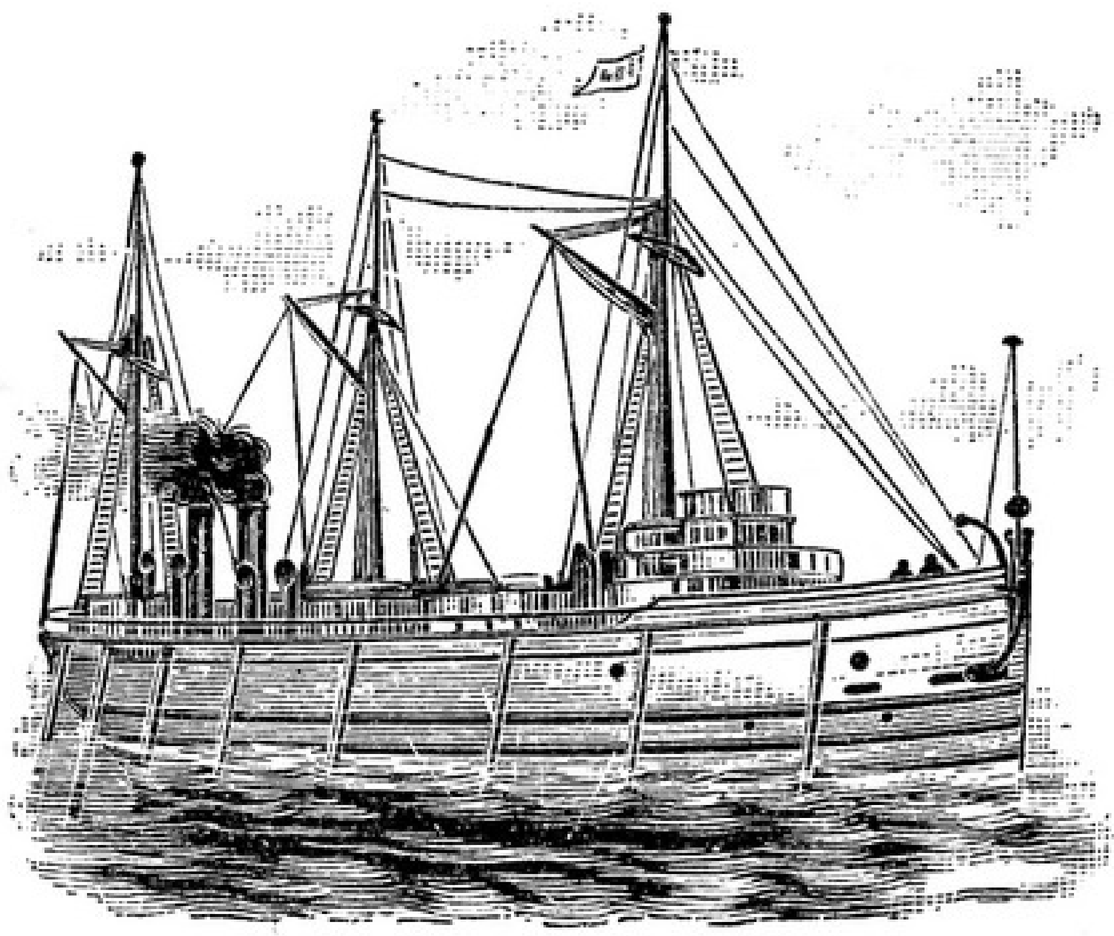

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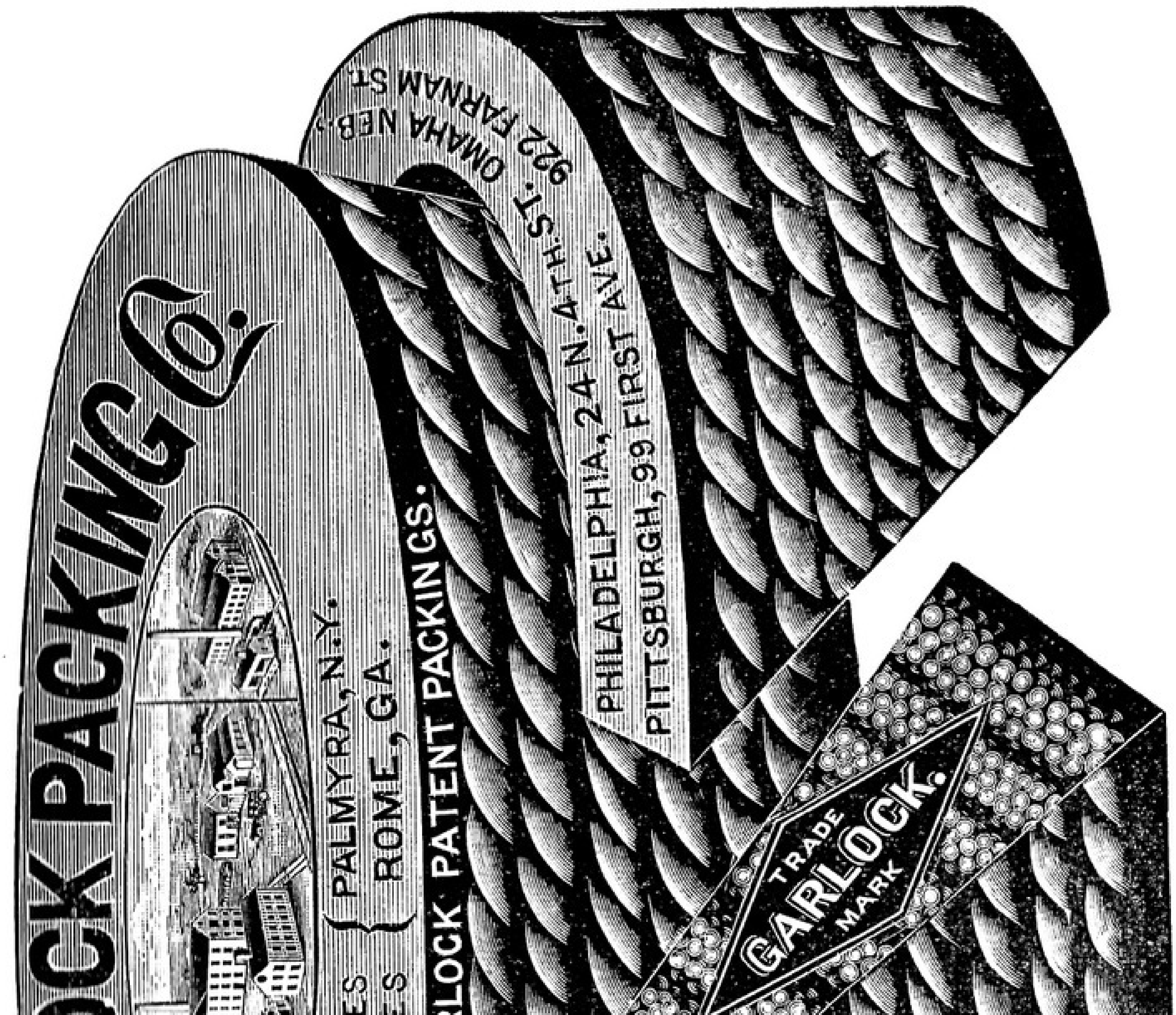

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SIGNS USED IN CALCULATIONS.

$=$ Equal to, as 12 inches $=$ 1 foot, or 2 added to $5=7$.

$+$ Plus, signifies addition, as $4+6=10$.

$-$ Minus, signifies subtraction, as $15-5=10$.

$\times$ Multiplied by, signifies multiplication, as $8\times 9=72$.

$\div$ Divided by, signifies division, as $16\div 4=4$.

: :: Signifies proportion, as $2:4::8:16$, that is, 2 is to 4 as 8 is to 16.

$\sqrt{}$ Signifies that the square root of the number or symbol to which it is prefixed is required; as $\sqrt{16}=4$.

$\sqrt[3]{}$ That the cube root is required; $\sqrt[3]{27}=3$.

5^2 Signifies that 5 is to be squared; $5^2=25$.

5^3 Signifies that 5 is to be cubed; $5^3=125$.

—— The vinculum or bar, signifies that the numbers or symbols over which it is placed are to be taken together; as, $\overline{3+6}\times 5=45$.

. Decimal point, as $.1=\frac{1}{10}$; $1.4=1\frac{4}{10}$.

( ) Parenthesis, signifies that all the numbers or symbols between are to be taken as if they were only one.

° ′ ″ Signify degrees, minutes and seconds.

′ ″ Signify feet and inches.

In arithmetic, addition is the process of finding the *sum*, subtraction of finding the *remainder* or *difference*, multiplication of finding the *product*, and division of finding the *quotient*.

The first triple expansion engine was built in 1874, designed by A. C. Kirk, of Liverpool, and placed in the steamer *Propontis*. Asa Taylor, of Newcastle-on-Tyne, in 1877, built a triple expansion engine for the yacht *Isa*. The high pressure cylinder was placed on top of the intermediate, both pistons being on the same rod, and exerting their power on a single crank, the low pressure being connected the same as an ordinary fore and aft compound to a separate crank.

DECIMAL EQUIVALENTS.

ONE INCH AS A WHOLE NUMBER.

$\frac{7}{8}$ and $\frac{1}{16}$=.9375	$\frac{1}{2}$ and $\frac{1}{16}$=.5625	$\frac{1}{4}$ =.25
$\frac{7}{8}$ =.875	$\frac{1}{2}$ =.5	$\frac{1}{8}$ and $\frac{1}{16}$=.1875
$\frac{3}{4}$ and $\frac{1}{16}$=.8125	$\frac{3}{8}$ and $\frac{1}{16}$=.4375	$\frac{1}{8}$ =.125
$\frac{3}{4}$ =.75	$\frac{3}{8}$ =.375	$\frac{1}{16}$ =.0625
$\frac{5}{8}$ and $\frac{1}{16}$=.6875	$\frac{1}{4}$ and $\frac{1}{16}$=.3152	$\frac{1}{32}$ =.03125
$\frac{5}{8}$ =.625		

ONE FOOT OR TWELVE INCHES AS THE WHOLE.

11 inches=.9166	5 inches=.4166	$\frac{3}{4}$ of inch=.0625
10 " =.6338	4 " =.3333	$\frac{5}{8}$ " " =.05208
9 " =.75	3 " =.25	$\frac{1}{2}$ " " =.04166
8 " =.6666	2 " =.1666	$\frac{3}{8}$ " " =.03125
7 " =.5833	1 " =.0833	$\frac{1}{4}$ " " =.02083
6 " =.5	7 " =.07291	$\frac{1}{8}$ " " =.01041

To reduce a proper fraction to a decimal: Rule.—Annex a cipher to the numerator of the fraction and divide by the denominator; if there be a remainder, annex another cipher and continue division, annexing ciphers until the division terminates without a remainder, or until as many decimals as are considered necessary are found. The quotient with the decimal point before it will be the value of the fraction in decimals.

Example—

Reduce $\frac{3}{8}$ to a decimal. 8)3.000
.375=$\frac{3}{8}$

Reduce $\frac{1}{16}$. 16)1.0000
.0625=$\frac{1}{16}$

11 inch=$\frac{11}{12}$ of 1 foot. 12)11.0000
.9166

$\frac{1}{8}$ inch=$\frac{1}{96}$ of 1 ft. 96)1.00000
.01041

THE screw propeller was first proposed by Hooke, in 1860, and between that time and 1835 many propositions to use, and several patents were issued in different countries. Col. John Stevens, of Hoboken, N. J., experimented with a screw in the Hudson River as early as 1804. In 1836 Capt. John Ericsson and Francis P. Smith, of Hendon, Eng., brought out their screw propeller, and by their energy and ability forced it upon the attention of the world and proved its merits.

$\sqrt{}$ SQUARE ROOT.

If a number be multiplied by itself, the product is the *square* of that number; and if that product be multiplied by the same number, the product is the cube of the number. To find or extract the *square* root of a given number is to find a number which, when squared or multiplied by itself, shall reproduce the given number. The rule is, commencing at the right we divide the given number into periods. If the number of figures are even, we have two numbers in each period; if odd, there will be but one in the first period on the left. The rule will best be followed by means of an example.

Desired, the $\sqrt{459684}$. Having divided the number into periods, proceed by finding the square root of the first period, or the root of the square nearest to it, but which must not be greater than the number in the period. The nearest square of 45 in the first period is the square of 6, which is 36, and 6 will be the leading figure of the root, and the square of it is subtracted from the first period. We bring down the next period, 96, to the right of the remainder 9, and that number will be the first dividend, and for a partial divisor we take twice the sum of the root just found, which is 12. This partial divisor, as in common division, will suggest the next figure for the quotient, which will be 7. We now annex the 7 to the root already found and to the partial divisor to form a complete divisor; then multiply 127 by 7, subtract the product from the dividend, and bring down the next period, 84, to the right of the remainder, 107. For the next partial divisor, double the two figures of the root already found, which gives 134 as the third figure for the quotient, which is 7. Annex this to the quotient and also to the partial divisor. Multiply 1348 by 8, the last figure in the root, and subtract the product from the dividend. There being no remainder, therefore 678 is the exact square root of 459684.

$$
\begin{array}{rl}
 & 459684(678 \\
 & \underline{36} \\
127) & 996 \\
 & \underline{889} \\
1348) & 10784 \\
 & 10784
\end{array}
$$

$\sqrt[3]{}$ CUBE ROOT.

To find or extract the cube root of a given number is to find a number that when cubed will reproduce the given number. The rule is, commencing at the right, point off the given number into periods of three numbers if a whole number; if a decimal, point off from left to right. Having pointed off the given number, put down for the first number of the root the number whose cube is the greatest cube of the first period and subtract its cube from the first period. To the remainder annex the next period, which will give a number forming a dividend. Square the root already found and multiply by 3 to form a divisor. Find how often this divisor is contained in the dividend *without the two right hand numbers* and put the result next to the root already found. The next three lines are obtained as follows: First, cube the last number in the root; second, multiply all the numbers in the root by 3 *except* the last and that product by the square of the last; third, multiply the divisor by the last figure in the root. Set down these lines under each other, advancing each line one place to the left. Add them and subtract their sum from the dividend. Bring down the next period to form a new dividend, form a new divisor and find another figure of the root by the same process.

Example.—Desired, the cube root of 34645976.

$$
\begin{array}{rl}
 & 34\dot{6}45\dot{9}76\dot{}(326 \\
3\times3\times3= & 27 \\ \hline
3\times3\times3=27) & 7645 \\ \hline
2\times2\times2= & 8 \\
3\times3\times4= & 36 \\
27\times2= & 54 \\ \hline
 & 5768 \\ \hline
32\times32\times3=3072) & 1877976 \\ \hline
6\times6\times6= & 216 \\
32\times3\times36= & 3556 \\
3072\times7= & 18432 \\ \hline
 & 1877976
\end{array}
$$

Having pointed off the given numbers, we find that the cube of 3 is the greatest cube of the first period, 34. Subtracting its cube, 27, from 34, the remainder is 7, to the right of which bring down the next period, 645, which forms a dividend. Multiplying the square of 3 by 3 we get the divisor 27, which is contained in 76 two times (the two right-hand figures being omitted). Place the 2 next to the 3 for the second figure in the root in forming the next three lines. 8 is the cube of 2, 36 is $3 \times 3 \times 2^2$, 54 is the divisor, 27 multiplied by 2, the last obtained figure in the root. The sum of the three lines as placed is 5768. Subtracted from the first dividend, we get 1877 for a remainder. Bring down the next period, 976, to form another dividend. The next divisor, 3072, is the square of the partial root $32^2 \times 3$, and is contained in 18779 six times, which forms the third figure of the root. In the next three lines 216 is the cube of 6, the last figure in the root. 3456 is the product of $32 \times 3 \times 6$ squared, 18432 is the divisor, 3062×6, the last figure in the root. The sum of the three lines is 1877976. There being no remainder, 326 is the exact cube of 34645976. Should there be a remainder, the given number has no exact cube. By adding ciphers the process may be continued to any desired number of decimal places.

When the sum of the three lines is greater than the dividend, it is necessary to put down as the figure in the root one less than the quotient.

TABLE OF SQUARES AND CUBES FROM ONE TO TWELVE.

No.	Square.	Cube.	No.	Square.	Cube.
1	1	1	7	49	343
2	4	8	8	64	512
3	9	27	9	81	729
4	16	64	10	100	1000
5	25	125	11	121	1331
6	36	216	12	144	1728

RATIO AND PROPORTION.

In comparing numbers or sizes with each other to find how many times one is contained in the other, or how much one is greater than the other, we divide one quantity by a similar quantity. The quotient so obtained will be the *ratio* one bears to the other. Thus the ratio of 12 to 4 is 3. The numbers thus compared are called the terms of the ratio. The first term (the dividend) is called the *antecedent*, the second (the divisor) its *consequent*. The ratio of two terms is expressed by placing a colon between them: thus, 12 : 4; or it may be expressed as a fraction, $\frac{12}{4}=3$. A direct ratio is the quotient of the antecedent divided by the consequent. An inverse ratio is the quotient of the consequent divided by the antecedent, as $\frac{4}{12}=\frac{1}{3}$. A simple ratio is the ratio of two numbers, as 8 : 4. A compound ratio is the product of two or more simple ratios, as 8 : 4 and 7 : 3, and is expressed thus: $\begin{matrix}8:4\\7:3\end{matrix}$ or $\frac{8}{4}\times\frac{7}{3}=\frac{56}{12}=4\frac{2}{3}$.

Example.—A triple expansion engine having cylinders 22, 35 and 56 inches in diameter, what would be the ratio of the H. P. cylinder to the L. P. cylinder? Now the areas of circles vary as the squares of their diameters, and by dividing the square of the diameter of the L. P. cylinder by the square of the diameter of H. P. cylinder, we find the ratio, or number of times one is greater than the other. Thus, $56^2=3136$ and $22^2=484$, and $3136\div484=6.48$, or about 6.5 to 1. The ratio of the H. P. to the I. M. P. is $35^2=1225\div484=2.5$ to 1.

To find the consequent, the antecedent and the ratio being known. Rule: The antecedent divided by the ratio equals the consequent ratio. Example—A low pressure engine having two cylinders (fore and aft) each 36 inch diameter is to be converted into a triple expansion engine by placing a H. P. and an I. M. P. on top, the two 36-inch cylinders combined to be used as a L. P. cylinder. The ratio between the L. P.

and H. P. to be 6.5, what would be the required diameter of the H. P. cylinder? The antecedent is represented by the sum of the squares of the two 36-inch cylinders. Dividing that sum by 6.5 we have $36^2+36^2=2592\div6.5=395.7$, which equals the square of the diameter of the cylinder required. Extracting the square root of 395.7 we get 19.9, the diameter in inches of the cylinder required.

To find the antecedent, multiply the consequent by the ratio. The product will be the antecedent. In the preceding example we find the diameter of H. P. cylinder required to be 19.9. What must be the diameter to make the ratio 2.5? $19.9^2=395.7\times2.5=989.75$, the square root of which, 31.45, equals the diameter of I. M. cylinder. One engine would be 20-inch, 31.5-inch and two 36-inch, the ratios being those usually adopted by engine builders.

PROPORTION.—Ratio is a comparison of two quantities, proportion a comparison of four quantities. When two pairs of numbers have the same ratio, the four numbers involved are said to form a proportion. Thus 6, 3, 8, 4, are proportionals because $6\div3=8\div4$ and is written 6 : 3 :: 8 : 4, and is read as 6 is to 3 so is 8 to 4. The first and fourth terms of a proportion are called the *extremes*, the two middle terms the *means*. When three terms of a propotion are given, to find the fourth, write the three given terms in a row, taking care that the *third* term is a *quantity* of the same kind as the required *fourth* term; and also that according as this fourth term is to be greater or less than the third, so must the second of the given terms be greater or less than the first term. Now multiply the third term by the second; divide the product by the first term, the quotient will be the required fourth term.

Example: The strength of shell is proportional to its thickness. For example, we have a boiler .5 inches thickness of plate, being allowed a safe working pressure of 90 lbs., what would be the required thickness for a safe working pressure of 135 lbs., the diameter being the same in both. The required

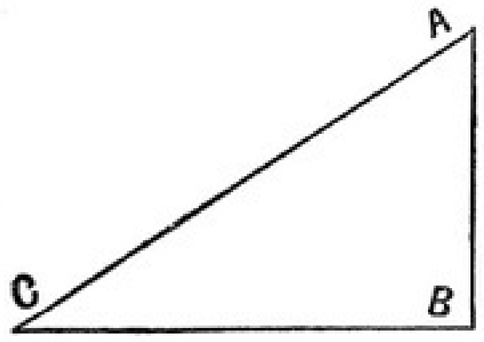
fourth term being greater than the given third term; the second term must be greater than the first, and the proportion would be stated as follows: 90 lbs. : 135 lbs. :: .5 : inches, the thickness required. Multiplying the second term by the third and dividing by the first term,

$$\frac{135 \times .5}{90} = .75 \text{ or } 90 : 135 :: .5 : .75 = \text{the thickness required.}$$

Example: A tubular boiler 60 inches diameter, 18 ft. long, fitted with 46 4-inch tubes has a heating surface of 1055 square feet. What would be the heating surface in boiler 12 ft. long, other dimensions being equal. 18 : 12 :: 1055 : 704.

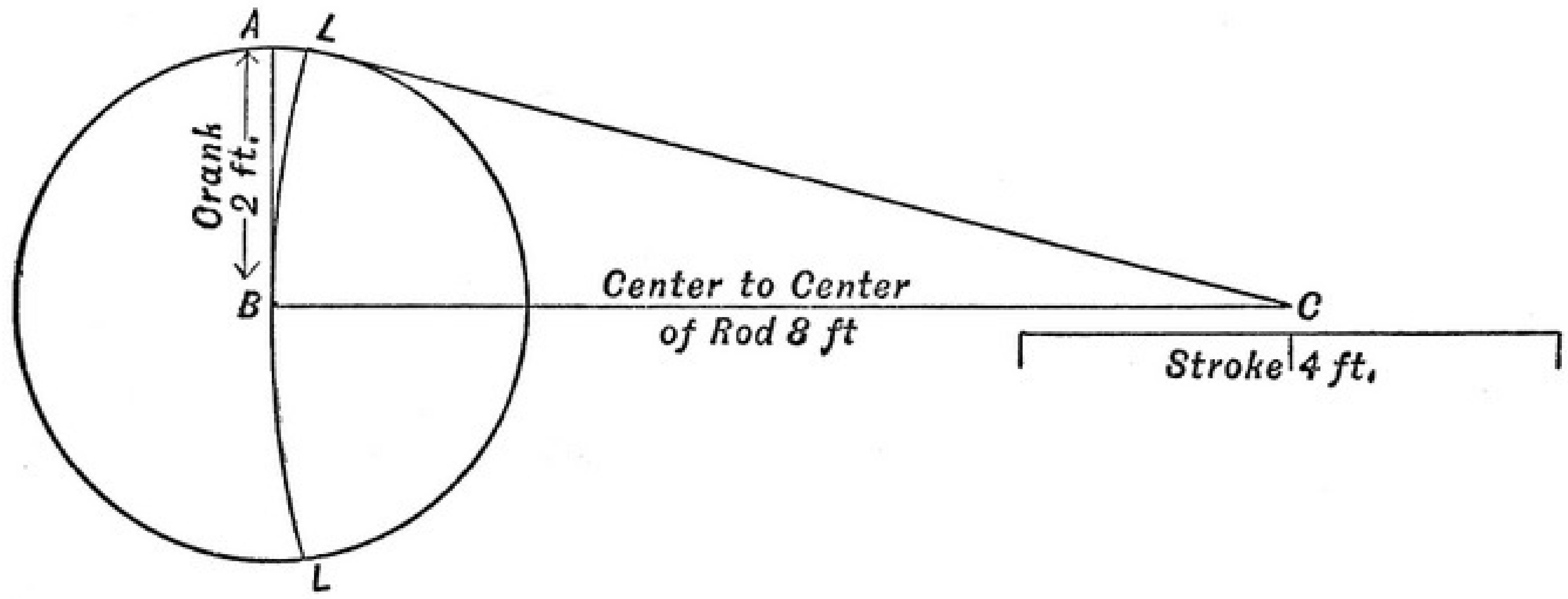
47th PROPOSITION.

There are some facts in connection with that particular kind of triangle called a right-angled, that are interesting to engineers. In the 47th proposition, Euclid has proved the fact that in every triangle having a right angle, the space enclosed by a square constructed upon the hypothenuse, or that side of the triangle opposite the right angle, is equal to the sum of the two squares constructed upon the other two sides. Thus, a square erected upon the side A C, which is the hypothenuse, will equal the space enclosed by the squares erected on the other sides A B and B C. To find the length of the hypothenuse add the sum of the squares of the two sides A B and B C and extract the square root of the sum, which equals the length of the side A C. Supposing the side A B to be 16 in. and the side B C 12 in., to find the length of the side A C we have $16^2 + 12^2 = 400$, the square root of which is 20, = length of A C. The same rule will do for pipes. To find the diameter of a pipe that will give an equal area of two smaller pipes. For example, required the diameter of a pipe to give an area equal to an 8-in. and 4-in. pipe, draw line B C 8 inches and B A at right angles 4 inches, the length from A to C will be the required diameter, or, by



extracting the square root of the sum of their squares, we have $4^2 + 8^2 = 80$, the square root of which is 8.854, or very nearly, and 9 inches would be the diameter required.

The area of a circle is equal to that of a right-angled triangle when the line A B is the radius, and the other, C B, is the circumference. The angularity of the connecting rod, as is well known, causes the piston to move faster at one part of the stroke and slower at the other, the variation being less as the length of the rod is increased in proportion to the length of the crank. With the cross-head at ½ stroke the length of connecting rod is represented by the line B C. Let

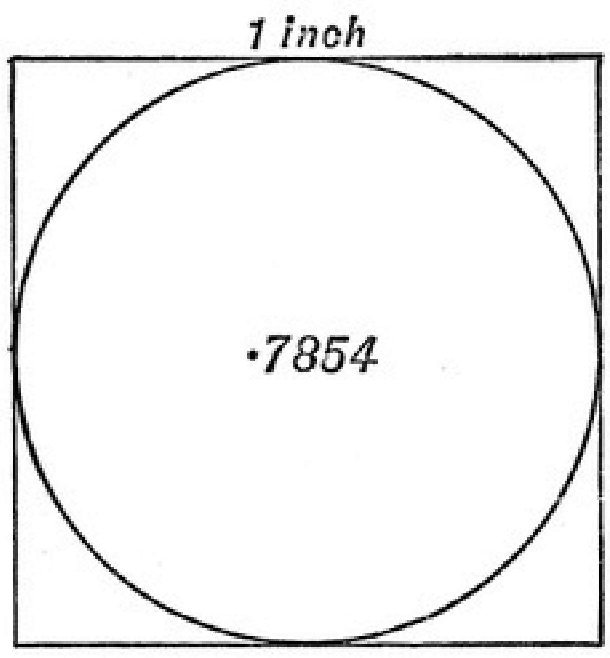


B A represent the crank at a right angle to B C. The rod being connected at the upper end, it is evident that it must make a curved line when swung out to the pin, it is also evident that the crank must travel farther, causing the piston to move faster at that part of the stroke farthest from the end of the cylinder. To find the distance between A and the curved line, reduce the length of crank and rod to inches, extract the square root of the sum of their squares, from the result subtract the length of rod in inches, the remainder will be the distance. Length of rod 96 in., crank, 24 in., $96^2 + 24^2 = 9792$, the square root of which is 98.95 and $98.95 - 96 = 2.95$ in. The center of crank pin A travels nearly 6 in. farther making the half turn from L to L than it does making the other half nearest the cylinder.

IT WAS good steammanship that brought the *Umbria* safely into port when she was rendered helpless by a broken shaft.

.7854.

The difference between a square and a circular inch:



1.0000	area of 1 inch square.
.7854	area of circular inch.
.2146	difference.

.7854 is obtained by dividing 3.1416 by 4, because as the line which bounds the square is to the line which bounds the circle so is the area of the square to the area of the circle. The line which bounds the square with 1 for its side is 4, and the line which bounds the circle with 1 for its diameter is 3.1416, which gives the proportion, 4 : 1 :: 3.1416 to the area of the circle. $1 \times 3.1416 \div 4 = .7854$, the area of a circle with 1 for its diameter. To find the area of a circle, multiply the square of the diameter by .7854. To explain the reason for multiplying the square of the diameter, we will suppose the above figure to represent a square of 1 foot, or 12 inches, with an inscribed circle, 12-inch diameter. To find the area of the square, we would square one side, thus: $12'' \times 12'' = 144$ square inches. As a circular inch contains but the $\frac{7854}{10000}$ of 1 square inch, we multiply the square of the diameter by .7854; thus, $12 \times 12 = 144 \times .7854 = 113.0976$ square inches. The difference between a *square* and a circular inch is .2146, and in 144 inches the difference is $144 \times .2146 = 30.9024$. Adding the last product to the area of the circle, we have $113.0976 + 30.9024 = 144$.

Conversely to find the diameter of a circle when its area is given, divide the area by .7854 and extract the square root of the quotient. Example.—Find the diameter of a circle having an area of 113.0976 inches. $113.0986 \div .7854 = 144$, the square root of which is 12, which equals the diameter.

To find the circumference of a circle, multiply the diameter by 3.1416. To find the diameter when the circumference is given, divide circumference by 3.1416.

The areas of circles are to each other as the square of their diameters. It is often desired to know how many pipes of a given diameter are required to equal the area of a larger pipe. Square their diameters, divide one by the other, and the quotient will be the number of pipes required. The number of 2-inch pipes required to equal the area of a 7-inch would be $7^2 \div 2^2 = 12$.

.5623.

To find cubic contents of a sphere or ball, we multiply the cube of the diameter by .5623. The reason we use .5623 is because as the line which bounds a cube is to the line which bounds the sphere, so is the area of the cube to the area of the sphere. The line which bounds the cube with 1 for its side is 6, and the line which bounds the sphere with 1 for its diameter 3.1416. So then we have this proportion: as the superficial area of a cube is to the circumference of the sphere, so is the diameter of the sphere to its cubical volume. $6 : 3.1416 :: 1 : x =$ area. $3.1416 \times 1 \div 6 = .5623$.

To find the surface of a sphere, multiply the circumference by the diameter.

As a capital test for sewer gas, employ unglazed paper saturated with a solution of one ounce of pure acetate of lead in half a pint of rain water. After partial drying, expose in the room. Sewer gas in any amount will darken or blacken the paper.

Queer combination of numbers—

$$\begin{array}{r} 142857 \\ 7 \\ \hline 999{,}999 \end{array} \qquad \begin{array}{r} 12345679 \\ 45 \\ \hline 61728395 \\ 49382716 \\ \hline 555{,}555{,}555 \end{array}$$

HORSE POWER OF ENGINES.

In calculating the horse power of an engine, a formula easily remembered is: $P = A \times S \times p \div 33{,}000$, or power=area $\times$speed$\times$mean effective pressure,$\div 33{,}000$; and for an engine 20 inches diameter of piston 36 inch stroke, 75 revs. per min. 40 lbs. M. E. P., power would be $314.16 \times 450 \times 40 \div 33{,}000 = 171.36$ H. P. The area of a 20-inch piston is 314.16 inches, the piston travel is 6 ft. for each revolution giving a speed of $6 \times 75 = 450$ ft. per minute. To find the piston speed required for a given H. P., the area of piston and effective pressure being known, Rule: Multiply the given H. P. by 33,000, divide the product by area of piston and the quotient by effective pressure, the result will be the piston speed required; dividing this by twice the stroke in feet gives the number of revolutions. Example: What would be the required piston speed per minute to develop 171.36 horse power, area of piston being 314.16 inches, mean effective pressure 40 pounds. $171.36 \times 33{,}000 \div 314.16 \div 40 = 450$ ft. per min.; $450 \div 6$, twice the length of stroke,$= 75$ revolutions per minute.

To find the diameter of piston required to develop a given horse power, the effective pressure, length of stroke, and number of revolutions being known. Rule: Multiply the power required by 33,000, divide the product by the piston speed in feet, and divide that quotient by the effective pressure, the result will be the required area of piston in inches. Divide that by .7854 and extract the square root of the quotient, the result will be the diameter of piston in inches. For example, it is desired to increase the horse power of an engine to 171.36 H. P. by putting on a new cylinder, the length of stroke being 36 inches, number of revolutions to be 75, giving a piston speed of 450 ft. a minute, and the effective working pressure to be 40 pounds, what would be the required diameter of the piston. Applying the rule, $171.36 \times 33{,}000 \div 450 \div 40 = 314.16 \div .7854 = 400$ the square root of which is $20 =$ diameter of piston in inches required.

THE SCREW PROPELLER.

That there is ample room for improvement in propellers is shown by the fact that not more than about one-half the indicated power of a marine engine is employed in driving the ship. To make this plain, we may take an example: Suppose that 18,000 indicated horse-power drives the "City of New York" at 22 miles an hour—that is, 1936 feet per minute. A thrust of 148,243 lbs., or 66 tons, moving at this velocity, represents 9,000 indicated horse-power, and accordingly the effort on each thrust bearing in the ship would, if it were possible to measure it, be found to be about 33 tons. If the whole indicated power were utilized in driving the ship, the thrust would be 66 tons on each bearing. Of the 18,000 horse-power, probably 15 per cent., or 2,700 indicated horse-power, is expended in overcoming the various frictional resistances of the engines and shafting. Fifty per cent., or 9,000 horse-power, goes to propel the ship, the remaining 25 per cent., or 6,300 indicated horse-power, is expended how? According to Rankine, principally on driving water astern in order to get thrust. Professor Greenhill, however, disputes the soundness of Rankine's theories. It is quite unnecessary for our purpose to go into this aspect of the question; besides the power expended unavoidably, and, in a sense, legitimately, on the water, we have apparently another and very important source of loss. We say apparently, because there is room for some doubt concerning its true magnitude. We refer to the friction of the propeller blades moving through the water. Let us assume that such a ship as the "City of New York" has a propeller 17 feet in diameter, which makes 82 revolutions per minute; the tips of the blade will then move through the water with a velocity of nearly 50 miles an hour, and it is easy to see that if the blades are of any sensible thickness they must meet with considerable resistance, to say nothing of the surface friction. Of course the deduction to be drawn is that the smaller in diameter, other things being

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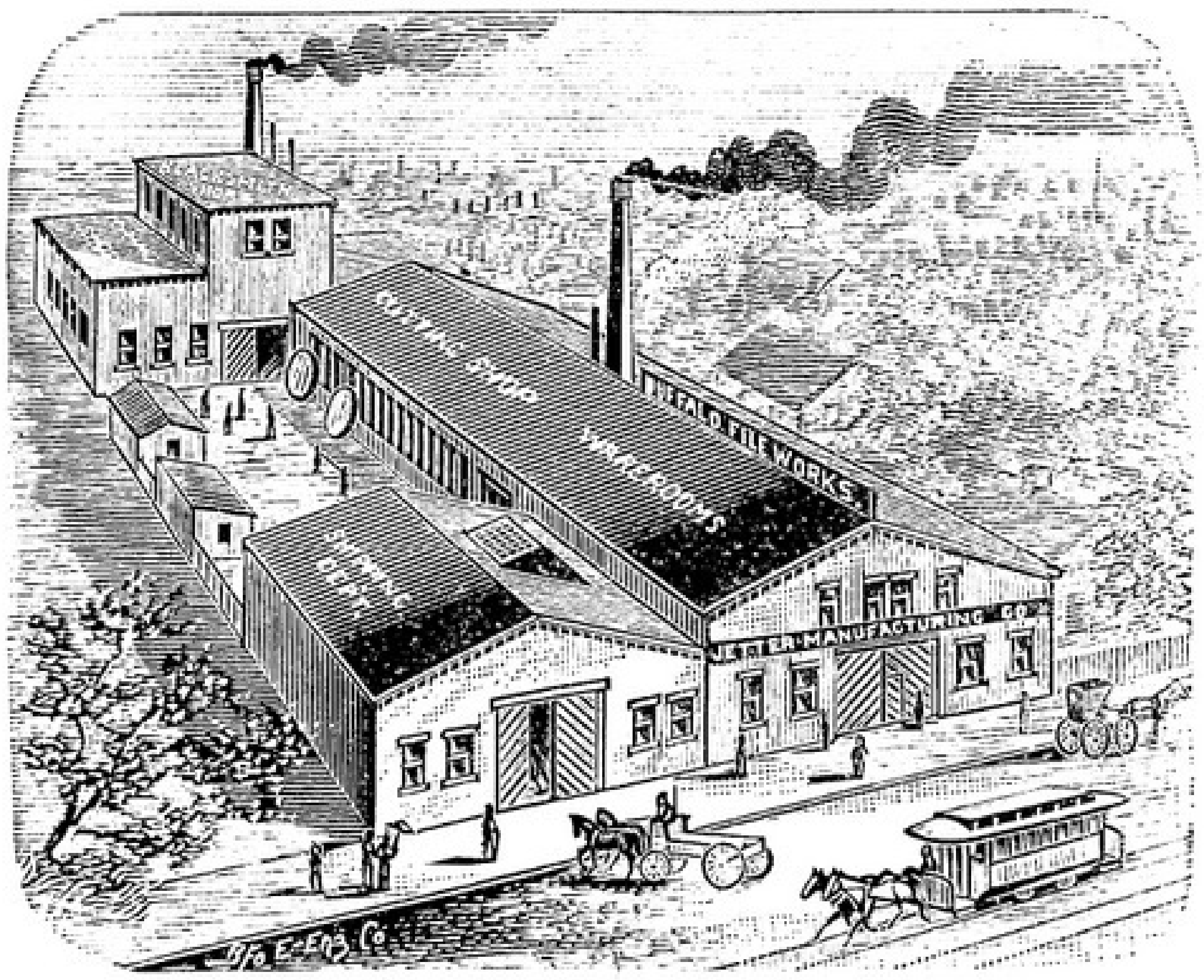

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equal, a screw can be made the better; and it is worthy of note that in almost every case where an improvement is effected by altering a screw propeller that alteration takes the form of a reduction in diameter. There is reason to believe that most ships are over-screwed. We cannot call to mind a single instance in which advantage was gained by an augmentation in diameter. We do not, of course, assert that such has not been the case, but only that it is outside our experience. This probably results from the prevailing tendency to provide plenty of screw area to reduce slip, which is looked upon as dead loss. Of course slip may or may not be a loss. It has, however, broadly speaking, little or nothing to do with the efficiency of the propeller, that propeller being most efficient which gives the greatest thrust in proportion to the indicated horse-power. We may have a propeller with a slip of 15 or 16 per cent., which gives a thrust representing 52 per cent. of the whole power exerted, and we may have another propeller with a slip of 5 per cent., which gives a thrust of only 48 per cent. of the gross power. The former screw would be the better of the two by 4 per cent. Some of the worst results ever obtained have been got with screws having a negative slip; but this was mainly due to the shape of the after body of the ship, and not to the screw.

We have expressed some doubt as to the hydraulic friction of the screw propeller being competent to account for the great disparity between the indicated horse-power and the thrust power, and the reason why is that just the same difference appears to exist between paddle-wheel thrust and indicated power. The paddle wheel wastes about 50 per cent. of the whole power. It is easy to prove this. It is well known that the propeller and the paddle wheel are about equally efficient.—*London Engineer.*

Is there is a stop valve on your boiler between the safety valve and the boiler? If there is, it had better be removed at once for reasons too numerous to mention.—*The Engineer.*

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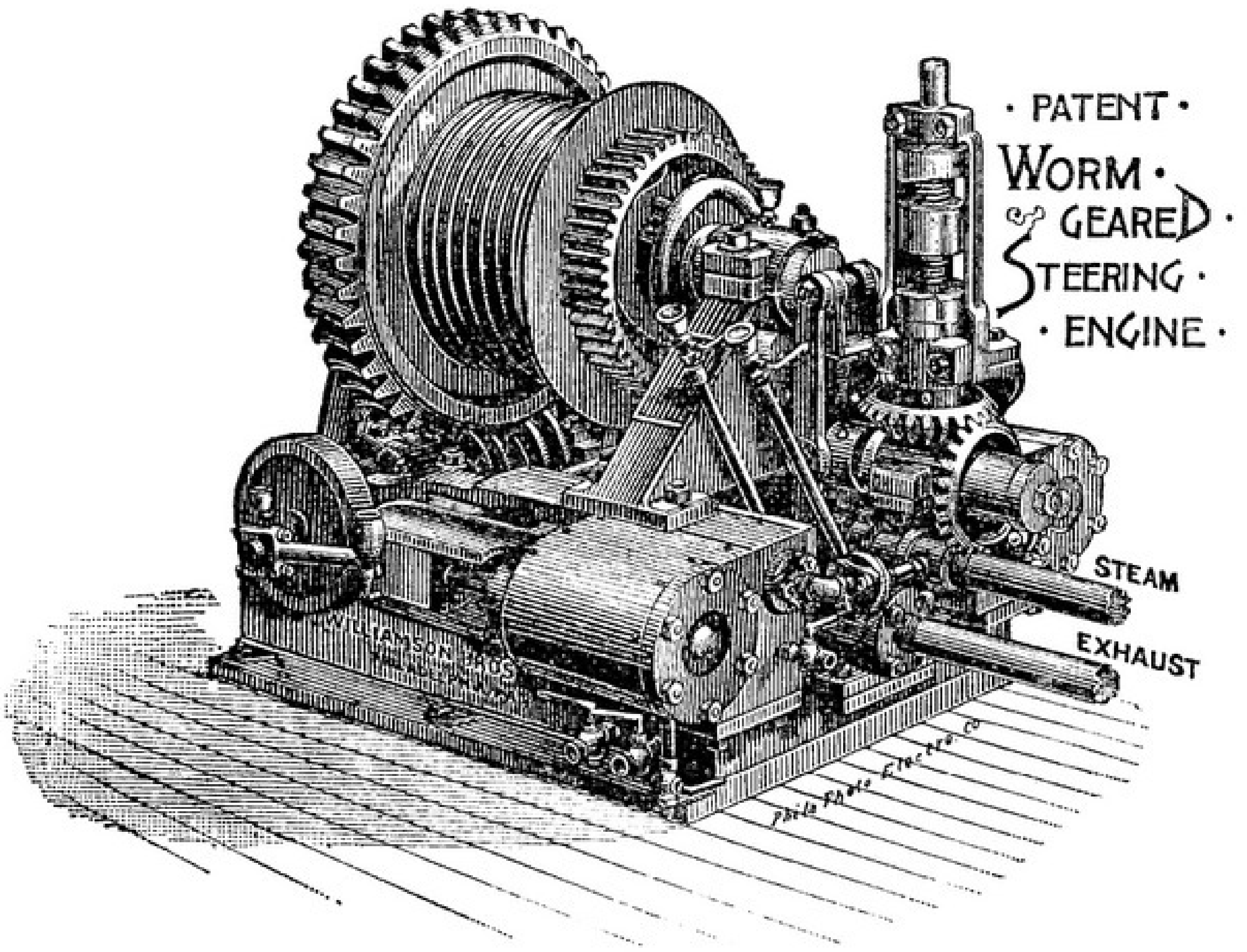

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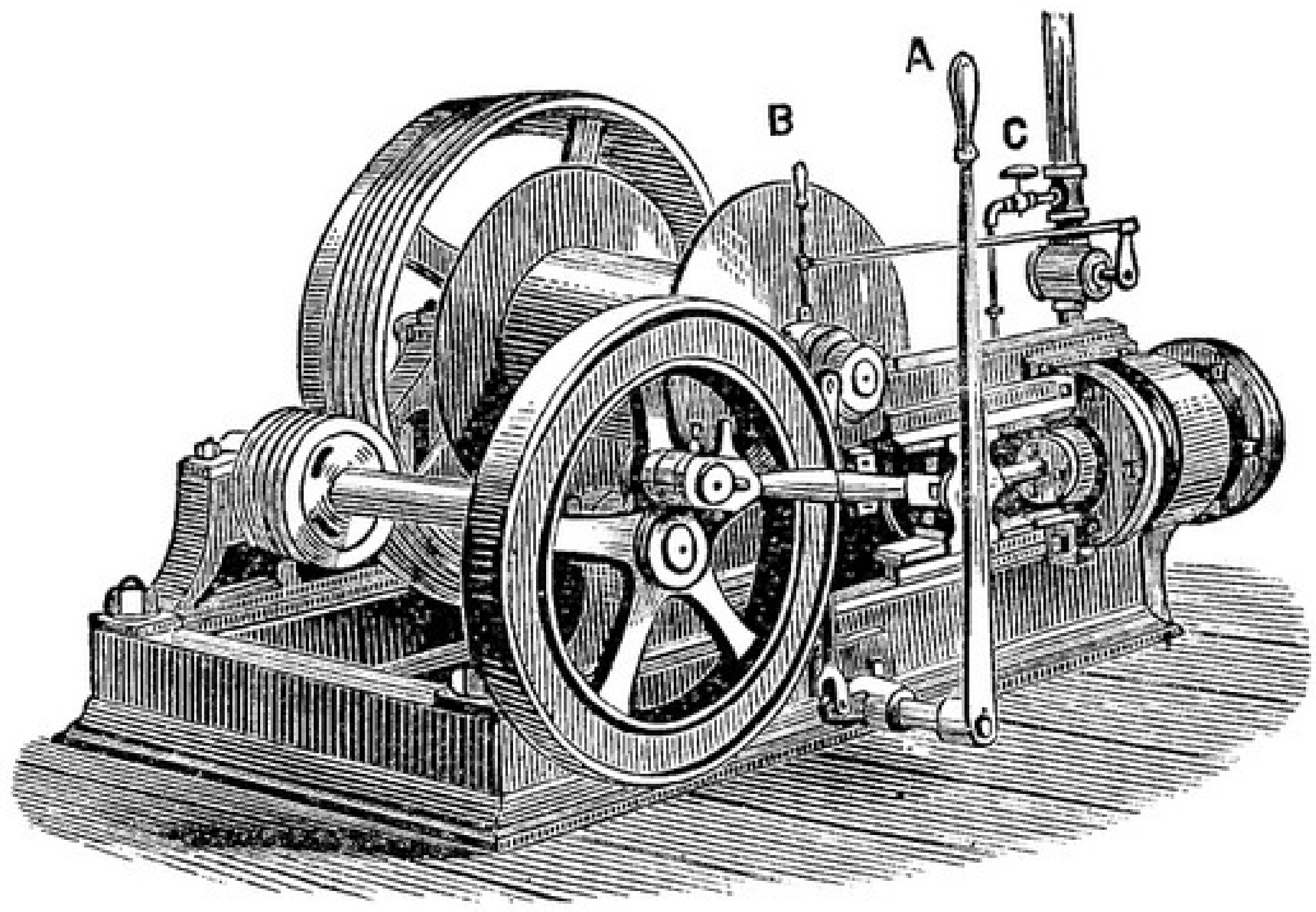

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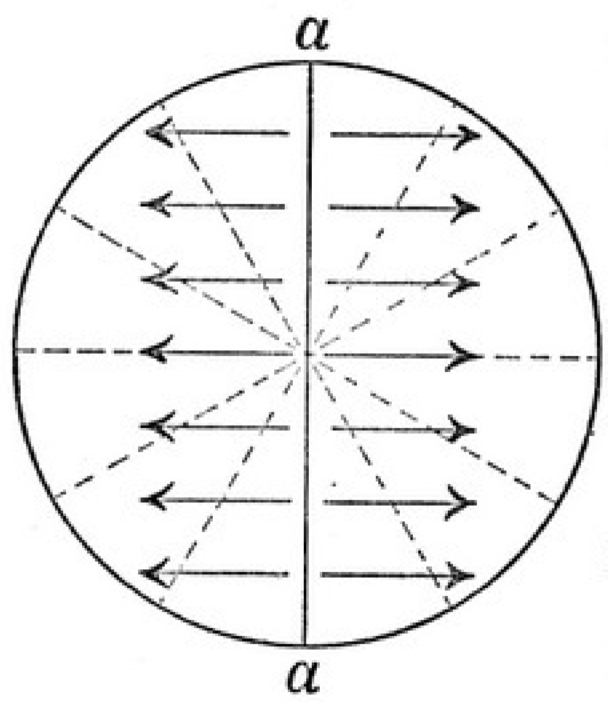
STRENGTH OF BOILERS.

The strength of a cylindrical shell is measured by the thickness of the plate and the diameter of the shell. The bursting pressure being determined by the following formula: $P=\frac{T \times t \times 2}{D}$ Where P=bursting pressure; T=tensile strength of material; t=thickness of material; D=diameter of shell in inches. Applying this rule to a shell 72 inches diameter, 3/8, or decimally .375 thickness of plate, having a tensile strength of 60,000 lbs. per square inch of cross section, we have $60{,}000 \times .375 = 22{,}500 \times 2 = 45{,}000 \div 72 = 625$ lbs. the bursting pressure. We multiply by .375 because the tensile strength is taken at a certain amount per square inch of sectional area, and the strength of a section of plate 1 inch wide and 3/8 thick, is 22,500 lbs. We have now found the strength of one side. As there are two sides we multiply by 2 and get 45,000; next divide by diameter. The reason for dividing by the diameter, 72, is best explained in the cut. Pressure on a cylindrical shell is exerted equally on the whole circumference, as shown by the dotted lines.



But the pressure or strain, tending to tear the shell apart would be in opposite directions, as denoted by the arrows. Taking a section of the shell 1 inch long and 72 inches diameter, the rupturing pressure would be exerted on a surface of 72 square inches. And that is why we divide by the diameter and get 625 lbs. as bursting pressure. If the diameter of this shell were doubled, its bursting pressure would be reduced one-half, the strength of the shell being inversely proportional to its diameter. Another rule giving the same results is, tensile strength $\times$ thickness $\div$ R, or half the diameter, equals bursting pressure. Here we find the strength of but one side of the shell, therefore divide by radius or 1/2 diameter, result being the same, 625lbs. The United States inspection law allows a safe working pressure 1/6 of the bursting

pressure, with 20 per cent. added for holes drilled and double riveted. The inspector's rule for finding the safe working pressure is as follows: $\frac{1}{6}$ of tensile strength multiplied by the thickness expressed in inches or parts of an inch, divided by the radius, the quotient equals safe pressure; add 20 per cent. for double riveted joint. Apply rule to preceding example: $\frac{1}{6}$ of tensile strength=10,000, the thickness .375 in., radius or $\frac{1}{2}$ diameter 36 in., therefore $10{,}000 \times .375 \div 36 = 104.16$, to which add 20 per cent. $104.16 + 20.83 = 124.99$ lbs. for double riveting.

The joint is not taken into consideration in the foregoing calculations, the strength of which Fairburn found by experimenting to be 56 per cent. of the solid plate for single riveting, and 70 per cent. of the solid plate for double riveting. Basing calculations on the strength of the longitudinal joint, the formulas used are: $P = \frac{T \times .70 \times t \times 2}{D}$ or $\frac{T \times .70 \times t}{R}$. Should the United States Senate Bill 1755, or the so-called Frye Bill become a law, the safe working pressure will be determined by these formulas.

SEC. 47. RULE FOR PRESSURE PERMISSIBLE IN MARINE BOILERS.—That the pressure for any boiler with a cylindrical shell to be used on vessels licensed by the United States shall be determined by the following rule: Multiply one-fifth of the lowest tensile strength found stamped on any plate of the cylindrical shell by the fraction which expresses the ratio of the strength of the longitudinal riveted joints to that of the solid plate; then multiply this product by the thickness, expressed in inches and parts of inches, of the thinnest plate in the same cylindrical shell and divide by the radius or half diameter, also expressed in inches, and the quotient will be the pressure allowable per square inch, provided that all other parts of the boiler shall correspond in strength to that of the shell, and that in no case shall the working strength of any material be taken higher than one-fifth of the ultimate strength.

The foregoing rule applies to the best material, with all the

rivet holes drilled and edges planed. If the rivet holes be punched, the edges sheared, or the workmanship defective, the factor of safety shall be increased by the inspector. The reamer, and not the driftpin, must be used to enlarge the holes, and the burr must be taken off the edges before the plates are riveted together.

To compare this rule with that now in use, we will take the data given in the foregoing examples, taking the strength of joint at 70 per cent. and we have $1,200 \times .70 \times .375 \div 36 = 87.5$ lbs. safe working pressure, where the rule now used gives a working pressure of 125 lbs. Should the bill become a law, there would be a reduction in this case of 37.49, or about 29 per cent., and there would be a general reduction of pressure on all marine boilers now in use of from 20 to 30 per cent.

COMPRESSION AND LEAD.

The following is an abstract from an article written by Mr. B. F. Ihsherwood, formerly Chief Engineer in the U. S. Navy, under the title of "Economy of Compression." He says: "The cushioning of back pressure steam is effected by the closing of the exhaust port of the cylinder before the piston reaches the end of the stroke, thus imprisoning whatever back-pressure steam then remains in the cylinder. The piston continuing to advance, compresses or 'cushions' this steam, increasing not only its pressure by the compression, but its sensible heat by the thermal equivalent of the work done by compression." Continuing, he says: "Notwithstanding the greatest practicable amount of cushioning, some steam lead is always found necessary to fill the waste spaces at the end of the cylinder, with steam of boiler pressure at the commencement of the stroke of piston. Were it not for the air mingled with the back-pressure steam, the 'cushion' curve would be much less than it appears on the indicator diagram." Concluding, he says: "There is an absolute

practical necessity, in order to avoid shock from concussion, to bring the piston and its attached parts to rest slowly as the end of the stroke is approached, and to have the waste spaces at the end of cylinder filled with steam of boiler pressure ready for the return stroke, and to have such an opening of the steam port as will maintain this pressure with the moving piston up to the point of cutting off the steam. All this is accomplished by giving the steam valve 'lead,' but this method entails a serious economic loss. The steam admitted during the lead simply adds to the back pressure against the forward pressure, and nothing is recovered from it, the additional back pressure is a total dynamical loss. Hence these waste spaces should be filled as much as possible by cushioned back pressure, and the 'lead' reduced to the minimum possible. In this way, if the setting of the valve has been judiciously done, a further gain can be indirectly made by cushioning."

THE OCEAN GREYHOUNDS.

RECORDS FOR FORTY YEARS.

Within the past forty years the steamship record from Liverpool has been lowered 40 per cent. The record from Liverpool was made in 1851 by the steamship Africa, which made a voyage to New York in ten days and six hours. The same year the record was broken three times—first by the Asia, which cut four hours from the time of the Africa; then by the Pacific, which crossed in 9 days, 19 hours and 25 minutes, and later by the Baltic, which made at that time the remarkable voyage of 9 days, 13 hours, and 42 minutes. The latter record stood until 1856, when the Persia reduced it to 9 days 1 hour and 45 minutes.

Next the Great Eastern was built, and the record since that day of length, breadth and horse-power of the greatest steamships in the world follow:

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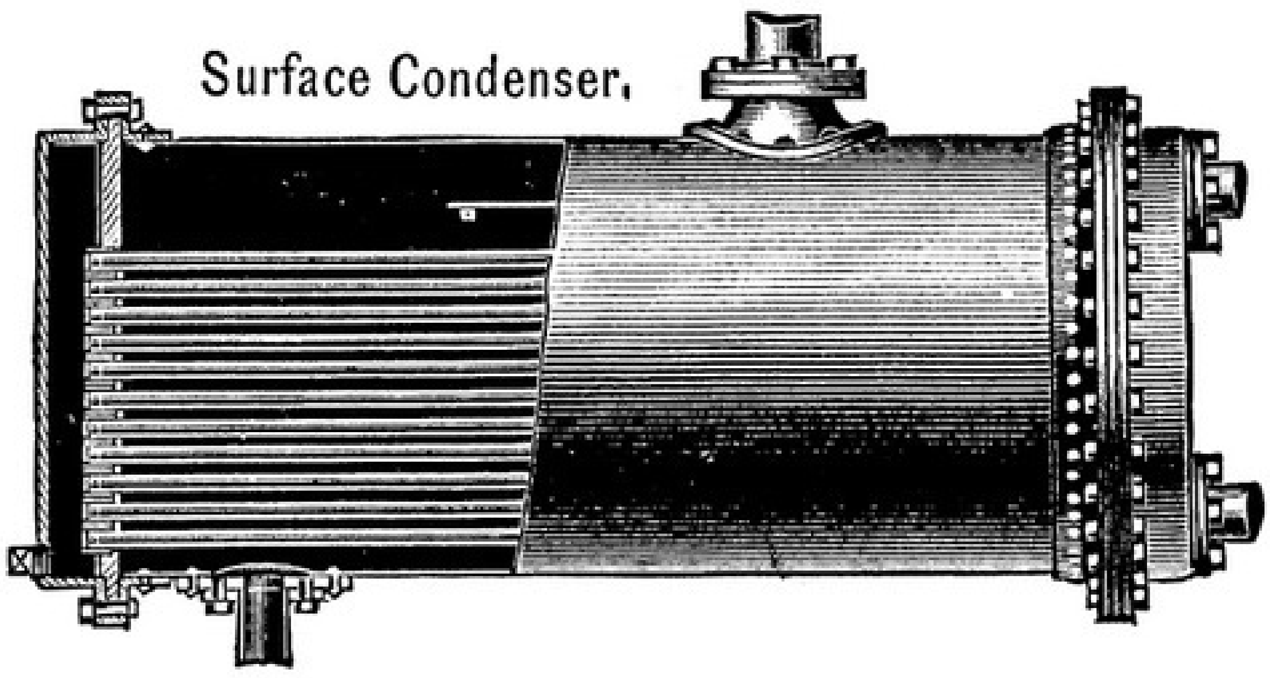

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AGENTS FOR VACUUM OILS.

NAME.	LENGTH. FEET.	BREADTH FEET.	HORSE POWER.
Great Eastern	680	82	7,650
Britannic	455	46	5,500
Arizona	450	45	6,300
Servia	515	52	10,300
Alaska	500	50	10,500
City of Rome	546	51	11,800
Aurania	470	57	8,500
Oregon	500	54	8,375
America	432	51	7,354
Umbria	501½	57.2	14,321
Lahn	465	49	9,500
City of Paris	560	63	20,605
Augusta Victoria	480	56	14,110
Columbia	480	56	13,680
Teutonic	550	57½	18,000
Normannia	520	57¼	16,352
Spree	485	52	13,000
Fuerst Bismarck	502½	57½	16,412
Campania	620	65.3	30,000

If rumors are true, the new ship which will belong to the White Star line will be 700 feet long and 70 feet beam. It is not necessary, however, to trust to rumors for proof of the advance in shipbuilding. The vessel of the Cunard line already launched will be known as the Campania, and will be 620 feet long and 65.3 feet breadth of beam.—*N. Y. Recorder.*

CONNECTING STEAM GAUGES.

A pressure of 1 ℔ per square inch is exerted by a column of water 2.3093 feet or 27.71 inches high at 62° Fahr. To find the difference in the pressure shown by the gauge, and the actual pressure in the boiler, when a gauge is so connected as to support a column of water. Divide the height of the column of water in inches by 27.71, the quotient will be the difference between the actual boiler pressure and the pressure indicated by the gauge. For example, a gauge connected with a pipe having a drop of 10 feet or 120 inches, the difference would be $120 \div 27.71 = 4.33$, and with a boiler pressure of 90 ℔s. the gauge would indicate 94.3 ℔s.

MEAN EFFECTIVE PRESSURE.

To find the mean effective pressure, without the use of an indicator diagram, a table of hyperbolic logarithms must be used. A full table of logarithms can be found in almost every Engineer's Text Book. When the required logarithm is found, it is a question of simple multiplication and division. First find the ratio of expansion by dividing the length of the stroke in inches by the distance the piston has traveled to the point of cut-off; find the hyperbolic logarithm of this ratio, which logarithm plus 1 is the ratio of gain; multiply that by the pressure of steam, and divide that by the ratio of expansion. The quotient minus the back pressure on piston = M. E. P.

Example: Steam pressure 130 lbs, stroke 48 inches, point of cut-off 12 inches. $48 \div 12 = 4$, hyp. log. of 4 is 1.38629, $1.38629 + 1 = 2.38629$, $2.38629 \times 130 \div 4 = 77.5$ lbs. mean effective pressure. Clearance has been omitted in the above example. Taking clearance at ½ inch we have $48 \div 12.5 = 3.84$, log. of 3.84 is $1.34547 + 1 = 2.34547 \times 130 \div 3.84 = 79.3$ M. E. P., minus back pressure on piston.

LIVE STEAM HEATERS.

Mr. John Kirkaldy gives the following interesting reasons for economy by using live steam heaters. In the first place no *heat* which has been drawn from the boiler to heat the feed water is lost. The steam used in giving up its heat to the feed water is condensed, this condensed steam passing to the boiler as water of the same temperature as the rest of the feed water.

The feed water on leaving the heater and entering the boiler is hot and very light and greatly expanded, and consequently rises to the surface rapidly, and is sooner converted into steam than would be the case with feed water at the usual low temperature of 130° F. for compound or 105° F.

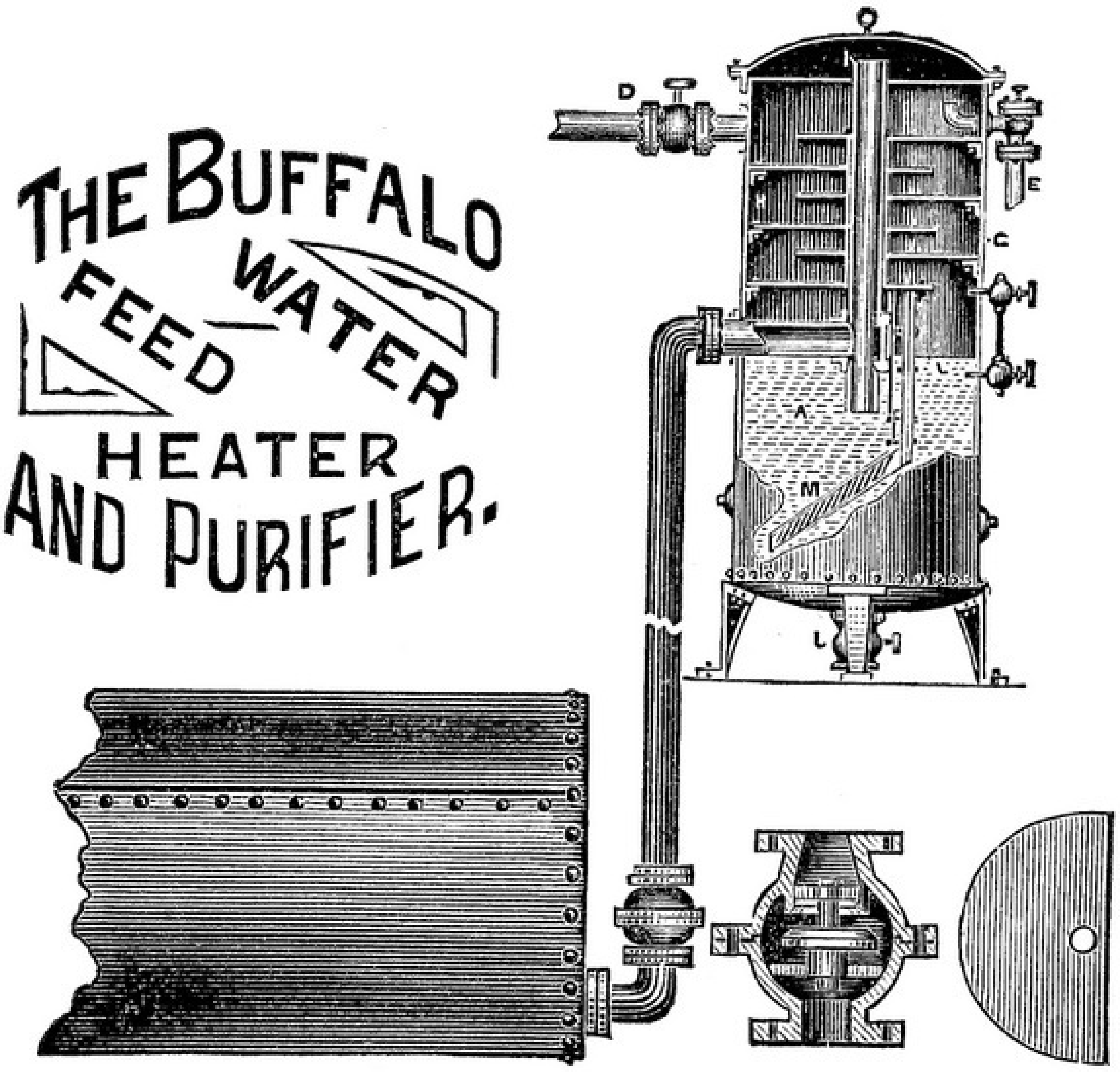
for triple expansion engines, ensuring that the water does not stagnate at the bottom of the boiler, as it certainly does where there is no heater on account of its gravity.

The heat passing through the heating surfaces is absorbed by the water in the boiler in considerably less time, causing economy in fuel and greatly benefiting the boiler by assimilation of the water entering with that already in the boiler.

It may be argued that there is loss of heat by radiation from the pipes between the heater and the boiler, but this is evidently very small and should be avoided entirely by properly protecting the pipes with a suitable non-conducting material, which, if neglected, cannot be considered a loss in any way chargeable to this method of heating feed water. Further advantages accrue to the boiler by freedom from leakages and decrease in the intense racking strains due to the great difference in temperature between the top and bottom of a boiler without a heater, and also the increased steadiness with which boilers fitted with heaters have invariably been found to steam. It is also another very valuable feature that grease and air are eliminated from the feed water and prevented from passing to the boiler to injure it, which they would in a marked manner if allowed so to do.

It is, I think, a fact that heating surface works more efficiently when evaporating water than when heating it, and also that in these heaters ("Compactum") the circulation is greatly improved, which, of course, violently agitates the water, and brings fresh currents constantly against the heated plates, enabling the maximum duty to be secured from the heating surface and utilizing it to the best advantage.—*Compactum.*

ACCORDING to Mr. Edward Atkinson, the well known stastician, it required 60,000 tons of cord to bind the wheat crop of 1891, amounting to 611,780,000 bushels. The corn crop for the same year was 2,060,164,000 bushels.



A—*Settling Chamber.* **B**—*Boiler.* **C**—*Feed Pipe to Boiler.* **D**—*Steam Pipe.* **E**—*Water Supply Pipe.* **F**—*Check Valve.* **G**—*Spray Disks.* **H**—*Spray Chamber.* **I**—*Equalizing Tube.* **J**—*Blow-off Pipe.* **K**—*Automatic Shut-off Valve.* **L**—*Division Plate.* **M**—*Deflector and Separator.*

This device, as shown in illustration and described below, is the result of careful study and practical experience. I have been convinced that the best way to keep a boiler clean is to prevent the sediment and scale-forming substances from entering into it with the feed water. This can be accomplished in two ways, viz: By filtration, and precipitation by gravitation. When filtration is the method used the filter soon becomes choked, thus preventing both water and sediment from passing through. In many cases bursting the pumps or pipes before the attendant is aware of the extra pressure that is accumulating inside of the purifier.

But when precipitation is the method used the larger the space occupied, the slower will be the current and the quicker the sediment will fall to the bottom by gravitation only. This is the method used in my apparatus. It is entirely free from danger, and is the only natural, safe, and simple way of accomplishing the desired object.

Not only are all substances having a higher specific gravity than water prevented from passing into the boiler, but those substances having a lower specific gravity are also excluded by the equalizing tube in the center, (extending below the surface of the water), thus preventing all substances that float on the surface from entering such tube.

This apparatus is also designed to neutralize a very serious danger, caused by the greatest enemy of a marine boiler, which entails the expend-

iture of large sums of money for repairs, and shortens the life of a boiler more than anything else, viz., unequal expansion.

The purifier is simple, durable and effective. It requires no skilled help to operate it. It is is only necessary to open the valve "J" once in six hours to blow the contents of the settling chamber out; also the blow-off valve on the bottom of the boiler once a week, and blow the water down about one gauge, when the boiler will be kept perfectly clean.

To remove the old or prevent the formation of new scale, no destructive boiler compound is needed, or extravagant waste of heat by blowing-off every hour, as is required by other devices.

Very respectfully yours,

ROBERT LEARMONTH,

No. 200 Bouck Avenue.

TABLE OF DIMENSIONS.

Numbers.	Diameter of Chamber.	Height of Chamber.	Diam. of Direct Steam Pipe D	Diameter of Feed Pipe E	Diam. of Supply Pipe to Boiler C	Diameter of Blow-off Valve J	Capacity per 30 lbs. Water a H.P. per Hour.
	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	
1	20	48	2	1½	2½	1½	80
2	20	54	2½	2	3	1½	100
3	24	54	2½	2	3½	2	125
4	27	54	2½	2	3½	2¼	150
5	30	60	3	2½	4	2½	225
6	30	72	3	3	4	2½	275
7	36	72	3½	3	4½	2½	400
8	36	84	3½	3	4½	2½	450
9	40	96	4	3½	5	3	650
10	42	108	4	3½	5	3	750

Where the engine develops a horse power with 20 pounds of water per hour, add 33 per cent. to the horse power given in the table.

TESTIMONIALS.

SCHOELLKOPF ANILINE & CHEMICAL CO.

P. O. Box 80.

Mr. Robert Learmonth. Buffalo, N. Y., January 5th, 1891.

Dear Sir: In reply to your inquiry, would state that your Feed Water Heater and Purifier is giving excellent satisfaction. The old scale is being gradually removed and no new scale is forming in the boilers. We expect to give you an order for another heater shortly. Yours truly, J. F. SCHOELLKOPF, *Secretary*.

THE UNION DRY DOCK COMPANY,

SHIP BUILDERS AND REPAIRERS.

Office, Ganson St.

Mr. R. Learmonth, C. E. Buffalo, N. Y., January 6th, 1891.

Dear Sir: We take pleasure in saying that the two Feed Water Purifiers you put on our boilers three months ago are doing all that you represented them to do.

We find the boilers, after being run for six weeks, to be as free from sediment of any kind as they were when last cleaned by our engineer.

We have not seen the inside of them for two months, and from outward indications it is not necessary to shut down to clean them. You are welcome to send anyone around to our boiler plant to examine and ask questions for themselves.

Sincerely yours, EDWARD GASKIN, *Superintendent.*

Mr. R. Learmonth, Buffalo, N. Y., January 12th, 1891.

Chief Engineer Anchor Line Steamers, Buffalo, N. Y.

Dear Sir: The purifier placed on the boiler of the Steamer China last spring, has proven highly satisfactory.

I cleaned the boiler but twice last season, and did not find as much mud as formerly when cleaned once each month.

I consider it of great benefit, too, on account of its producing a high temperature to the feed water, causing a more even expansion and contraction on all parts of the boiler.

Yours respectfully, JOHN WISE,

Chief Engineer Steamer China.

Mr. Robt. Learmonth, Buffalo, N. Y., December 31, 1891.

Buffalo, N. Y.

Dear Sir: I desire to advise you that the Buffalo Feed Water Heater and Purifier which you put on our shop boiler is a perfect success.

It removed the old scale and prevents the formation of new scale. It has effected a saving in coal, as the boiler steams more easily; also from the fact that it is not now necessary to draw the water from the boiler every few days for the purpose of "cleaning boiler."

I take pleasure in recommending your Purifier to all users of steam, and would say that since using it, I am convinced that I could not afford to be without it.

Yours truly, H. G. TROUT,

Proprietor King Iron Works.

Mr. Robt. Learmonth, Buffalo, N. Y., January 12th, 1892.

Buffalo, N.Y.

Dear Sir: In complying with your request to express my opinion regarding the four Buffalo Feed Water Heaters and Purifiers which we have in use on our Babcock & Wilcox boilers, would say, that after we had them in operation for three months, we found the old scale loosened from the sheets and no new scale forming.

We have had them now for nearly six months, and the boilers are entirely clean.

The apparatus not only acts as a purifier, but as an equalizer of temperature. The water discharging into the boiler at pressure of 90 pounds, has a temperature of from 290° to 310° Fahr., thus obviating the trouble caused by all unequal expansion, which I consider will greatly increase the durability of the boilers. I can cheerfully recommend them to all steam users. Very truly yours, J. E BECKMAN,

Chief Engineer Hotel Iroquois.

R. Learmonth, Esq. Buffalo, N. Y., January 22, 1892.

Dear Sir: In response to your inquiry as to the working of your Feed Water Heater and purifier, we take great pleasure in saying that it is the most perfect Feed Water Heater and Purifier we ever saw; all the impurities in the water are pre-

cipitated, and the water enters the boiler almost perfectly pure, at a temperature equal to that in the boiler.

We have used the Heater and Purifier for nearly two years, and we would not dispense with it at any cost. Yours truly,

LAKE ERIE BOILER WORKS,

Dictated by MR. R. HAMMOND. F. W. T.

ROBERT LEARMONTH, ESQ. BUFFALO, N. Y., February 15th, 1892.

DEAR SIR: In answer to your inquiry as to what results we obtained from working your Buffalo Feed Water Heater and Purifier, we would say that we are perfectly satisfied. Before using it we could not keep a clean boiler, which was a continual source of trouble, annoyance and expense, as the tubes in the boilers got choked with scale, etc., and had to be renewed. We tried various compounds, including Tri-Sodium-Phosphate, but with no good results. We sent sample of the water we use, also the scale found in boiler to the Keystone Chemical Works. Their chemist analyzed same and sent the following analysis.

ANALYSIS OF WATER FROM EXCELSIOR MACHINE CO., BUFFALO, N. Y.

Lime Carbonates,	2.86	grains per U. S. gallon
Lime and Magnesia Sulphates,	122.51	grains per U. S. gallon
Sodium Chloride, (salt)	10.53	grains per U. S. gallon
Iron Oxide, etc., Sodium Sulphate,	30.66	grains per U. S. gallon
Volatile and organic matter,	19.50	grains per U. S. gallon
Total solid matter,	186.06	

Remarks: Very strong smell, slightly turbid.

ANALYSIS OF SCALE.

Lime Carbonate and Magnesia,	9.06
Lime Sulphate,	87.38
Iron Oxide,	2.21
Sand and Silica,	1.35
Total,	100.00

This water is too heavily loaded with sulphates to be fit for use in boilers.

WILLIAM J. WILLIAMS, F. C. S., etc., Camden, N. J.

After running ten (10) weeks, we opened our boiler and found absolutely no scale and very little deposit, and that we could sweep out with a common broom.

As a proof of our satisfaction we enclose check for same.

Respectfully yours, EXCELSIOR MACHINE CO.

Dic. by JONES & ROUGHEAD, *Proprietors*.

MR. ROBERT LEARMONTH, BUFFALO, N. Y., December 14, 1892.

200 Bouck Avenue, Buffalo, N. Y.

DEAR SIR: At your request we herewith give you our experience with the No. 9 Purifier which you placed on our battery of seven boilers, at the Cummings' Cement Works, Akron, N. Y.

Previous to the Purifier being put on we could only run our boilers one week without cleaning, and even then the sediment would accumulate on the bottom, causing the shell to bulge down; also the tubes would become solid, and get overheated and loose.

We frequently had to take them out to remove the sediment, which made a continued expense for boiler work, besides the loss of time.

This year we have run the entire season without any loss of time or expense for boiler repairs.

We enclose herewith a copy of an analysis which we had made by a chemist in our endeavor to find some relief in the way of boiler compound, but found none.

You are at liberty to refer any person to us who may be in search of a purifier to remove the scale-forming substance from their feed water supply.

We can say that now we cannot afford to be without one.

Yours truly, PALMER CUMMINGS,

Manager Cummings' Cement Works, Akron, N. Y.

ANALYSIS.

The sample of water from Cummings' Cement Works at Akron N. Y., contains per 100,000 parts of water:

Matter insoluble, or made insoluble by heating,	47.6
Readily soluble solid matter.	101.6
Total solids,	149.2

or the very large amount of 86 97-100 grains to a U. S. gallon.

I find an excessive proportion of sulphates, considerable carbonates and a little chlorides, associated with lime, magnesia soda and potash, combined, as indicated by the analysis in the form of: Lime sulphate (gypsum), magnesia sulphate (Epsom salt), lime carbonate, soda chloride (salt), and in small amounts soda sulphate, potash sulphate, magnesia carbonate. I also found considerable iron oxide (rust), and a little silicious matter, but no appreciable organic material, ammonia or nitrates.

The water was clear on decanting, a little murky on shaking, and was somewhat alkaline.

Scale matter from this water will be mostly lime sulphate, with some considerable lime carbonate, some iron oxide and a little magnesia carbonate and silica.

Soluble part of the solid matter is largely magnesia sulphate and lime sulphate with some soda chloride and soda sulphate. Magnesia sulphate is present in notably large amount.

There is less soda chloride than might be expected.

PAINTING ENGINE ROOMS AND FITTINGS.

White paint in engine rooms and on all steam pipes and fittings, will make engine rooms much brighter and pleasanter and also much cooler. The science of heat teaches us that there is more heat radiated from black than there is from white surfaces. The objection to white paint is that it soon becomes discolored, and burns off by the action of the heat. That trouble may be avoided by mixing white lead with kerosene oil and giving those parts exposed to a high temperature several coats, and it will retain its color for a long time. It makes a good reflector when applied to the water-gauge column and its fittings. It is being used on some of our boats carrying 160 pounds of steam with perfect success.

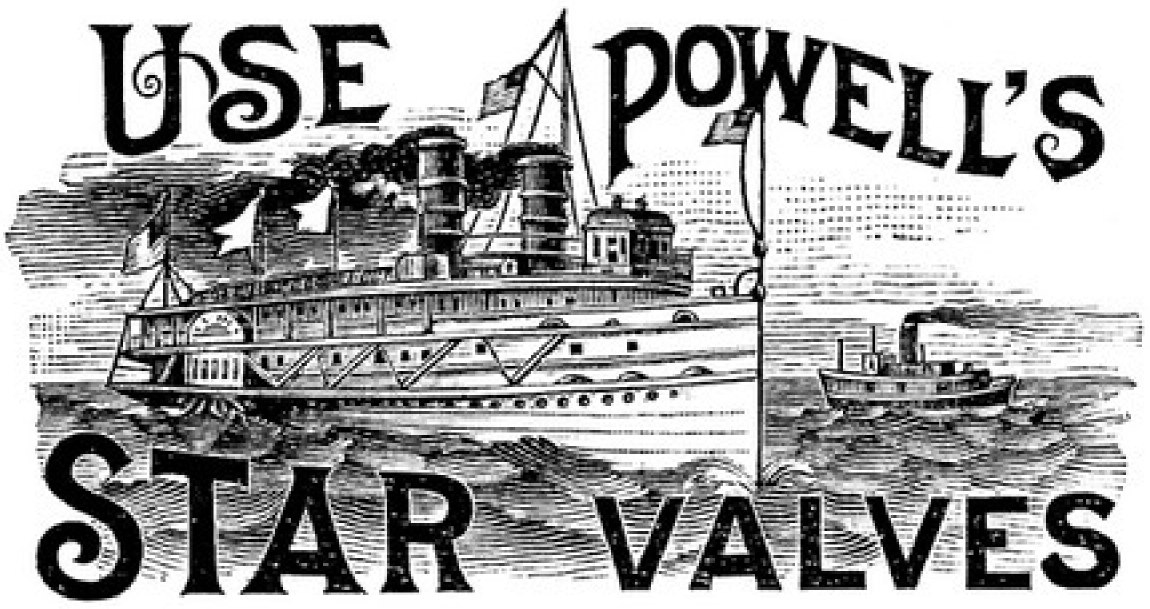
XXX.

STAYS AND BRACES.

Sec. 6 of Rule 2 of the Amended Steamboat Rules provides that no braces or stays be allowed a greater strain than 6,000 lbs. per square inch of section.

Taking the tensile strength of iron at 45,000 lbs. per square inch, the above rule fixes the factor of safety at $7\frac{1}{2}$. The strain on a stay depends on the surface it has to support, and the pressure on that surface. Example: Desired, the number of $\frac{7}{8}$ stays to support a flat surface 4 feet by 5 feet, boiler pressure to be 90 lbs. per square inch. Our first step is to find the number of square inches in the surface by multiplying the length by the width and the product by 144, the number of square inches in 1 square foot, and multiply that by the pressure, the last product being the total pressure on the surface. The strain allowed on each bolt is 6,000 lbs. per square inch of cross sectional area. A $\frac{7}{8}$ bolt measured at the bottom of thread would be $\frac{3}{4}$ in., and the sectional area of a $\frac{3}{4}$ bolt is .4417, and $.4417 \times 6000 = 2650$ lbs., strain allowed on $\frac{7}{8}$ bolt. Now divide the total pressure on the surface by 2650. The quotient will be the number of stays required. Numerically expressed, the example is $4 \times 5 = 20 \times 144 = 2880 \times 90 = 259200 \div 2650 = 97.8$, or 98 stays. To find the area that each stay will have to support, and the distance apart they will be when in place, first divide the number of square inches in the surface by the number of stays. $2880 \div 98 = 29.4$ inches, the area supported by each stay. Next extract the square root of the area supported. $\sqrt{29.4} = 5.4$ inches, which will be the pitch or distance from center to center of stays.

The pitch and pressure being known, the area of bolt required is found by the following formula: $\text{Pitch}^2 \times \text{pressure} \div 6000 = \text{area of bolt required}$. To find the strain per square inch of cross sectional area, the pitch, pressure and area of bolt being known, the following formula is used: $\text{Pitch}^2 \times$



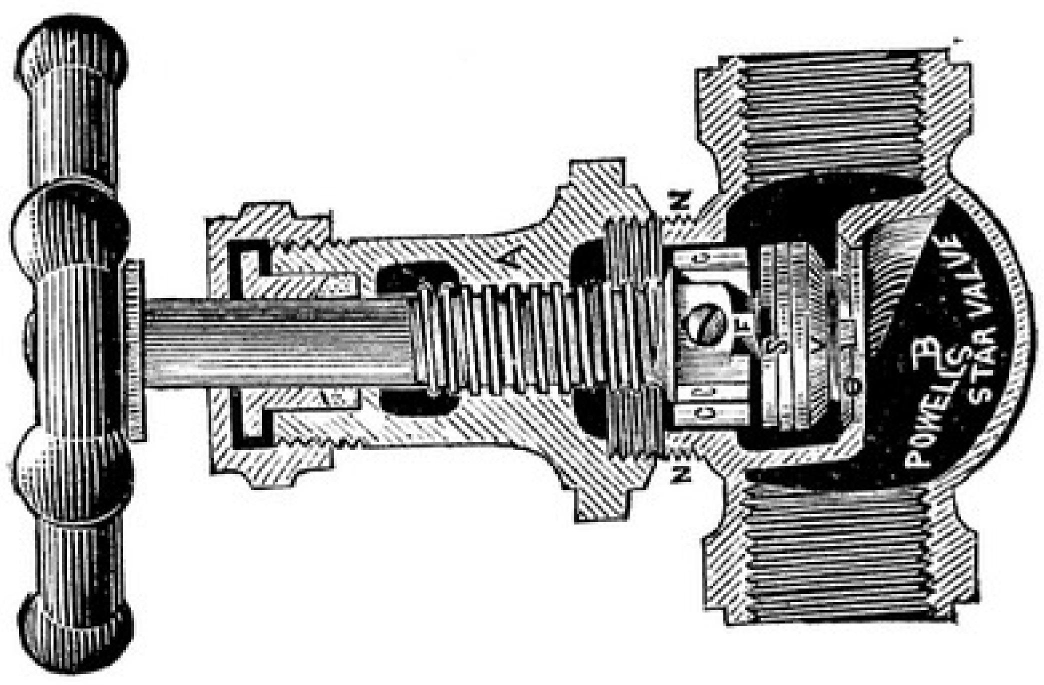
FOR
STEAMSHIPS,
TUGS,

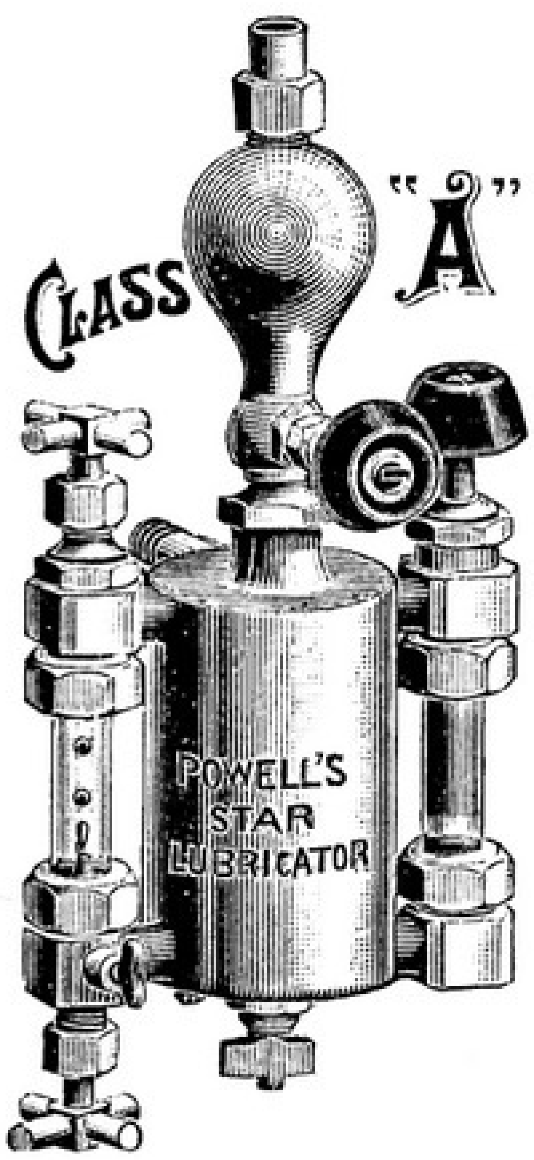
and all general purposes
where a good, reliable
valve is required.

WE WARRANT THEM TIGHT

They are
STRONG,
HEAVY &
DURABLE

Can be re-ground while in
position on the pipes.





POWELL'S PATENT

Class "A"

Sight Feed Lubricator

Best in the market for

STEAM ENGINES, PUMPS,
Etc., Etc.

HIGH GRADE GOODS AT MODERATE PRICES.

Any jobber in steam goods can supply you.

For Illustrated descriptive Catalogue, address

The WM. POWELL CO.

CINCINNATI, - - - - OHIO.

pressure $\div$ area of bolt = strain per square inch of cross sectional area.

A question sometimes asked is this: The bolt supporting two surfaces and the pressure on each surface being 90 lbs. per square inch, whether there would not be twice the amount of strain on the bolt than that given by the rule. One of Newton's laws of motion is that action and reaction are equal and opposite. To get a strain of 2000 lbs. both sheets must pull an equal amount in opposite directions. For instance, if a weight of 25 lbs. be suspended by a cord from a spring balance, the action of the weight would produce a strain of 25 lbs. The reaction of the spring would produce an equal strain in an opposite direction. Yet the strain on the cord would be but 25 lbs.

LENGTH OF MILES.

English speaking countries have four different miles—the ordinary mile of 5,280 feet, and the geographical or nautical mile of 6,085, making a difference of about one-seventh between the two; then there is the Scotch mile of 5,928 feet, and the Irish mile of 6,720 feet; four various miles, every one of which is still in use. Then almost every country has its own standard mile. The Romans had their millia passum, 1,000 paces, which must have been about 3,000 feet in length, unless we ascribe to Cæsar's legionaries great stepping capacity. The German mile of to-day is 24,318 feet in length, more than four and a half times as long as our mile. The Dutch, the Danes and the Prussians enjoy a mile that is 18,440 feet long, three and a half times the length of ours; and the Swiss get more exercise in walking one of their miles than we get in walking five miles, for their mile is 9,153 yards long, while ours is only 1,760 yards. The Italian mile is only a few feet longer than ours, the Roman mile is shorter, while the Tuscan and the Turkish miles are 150 yards longer.—*St. Louis Democrat.*

THE OTIS
TUBULAR
Feed Water Heater and Purifier

WITH SEAMLESS BRASS TUBES.

The only Tubular Heater with settling chamber below the tubes. The only Tubular Heater that will extract the oil from the exhaust.

WHAT WE GUARANTEE:

1st. One square foot of heating surface per horse-power.

2d. To heat the feed water 210° or 212° with the exhaust steam, without causing any back pressure.

3d. That it can be thoroughly cleaned through the manhole without disconnecting any pipes.

4th. A large Heater, with more heating surface and water capacity than any other heater, for less money.

5th. If the heaters do not fulfill our claims, there will be no cost to parties using them, and we will pay freight, cartage and all piping.

Also Patentees and Manufacturers of the **Red Jacket Steam Flue Blower** and **Boiler Feed Pumps.**

——SEND FOR CATALOGUE TO——

STEWART HEATER Co.

1014 Norfolk Ave., BUFFALO, N. Y.

New York Office, 112 Liberty St.

CHRONOLOGY OF STEAMBOATING.

The following chronological exposition of the origin, in-invention and introduction of the steamboat and steamship is given on the authority of the New York *Marine Journal:*

The first idea of steam navigation was contained in a patent obtained in England by Hull in 1783-4. Oliver Evans was the next experimenter in steam navigation in 1785-6. Ramsey was also an experimenter in Virginia in 1787. W. Symington made a trial on the Forth and Clyde with a small but rudely constructed model of a steamer in 1789. Chancellor Livingston built a steamer on the Hudson in 1797. The first experiment in steamboating on the Thames, Eng., was in 1801. Mr. Symington repeated his experiments on the Thames with success 1802.

Fulton built the steamer "North River," and made a passage up the Hudson river to Albany from New York in 33 hours—the first steam navigation on record. The engines were constructed by Boulton & Watts. The voyage was made in 1807. The next steamboat was the "Car of Neptune" in 1808. Fulton built the "Orleans" at Pittsburg—the first steamer on western rivers. It was completed and made the voyage to New Orleans, 2,000 miles, in 1811. The "Paragon" was the next steamer, built in New York in 1811. The "Richmond" was built in New York in 1812. The first steam vessels of Europe commenced plying on the Clyde in 1812. The "Vesuvius" was built at Pittsburg in 1813. Five steam vessels appeared in Scotland in 1813.

The first steam vessel to make a voyage up the Thames was brought to Glasgow by a Mr. Dodd in 1815. England built her first steamer in 1815. The "Savannah," the first steamer to cross the Atlantic was of 350 tons burden, and sailed for Liverpool from Savannah, Ga., July 15th, 1819. The first steamer in Ireland was in 1820.

Capt. Johnson was paid £10,000, or $50,000 for making the first voyage by steam to India. The voyage was made on

the steamer "Enterprise," which sailed from Falmouth, Eng., August 16th, 1825.

The "Great Western," from Bristol, Eng., and the "Sirius," from Cork, Ire., both arrived at New York City, each on her first voyage and each 18 days out, on June 17th, 1838. The first steamer of the Cunard Line to arrive on American shores was the "Britannia," which arrived at Boston after a passage of 14 days and 8 hours, in July, 1840. The first war steamer was built in England in 1838.

Returns from 23 states gave an aggregate of 700 steamboats in the United States in 1838. There were about 1,500 steam vessels in the United States in 1847. The "Washington" was the first American steamer of note. She made her first passage to Southampton, Eng., in June, 1847.

THE GREAT LAKES.

Few persons who have not made a personal study of the matter realize the magnitude of the traffic of the Great Lakes. There were over 1,100 more vessels passing through the canal into Duluth, Minnesota, in 1891 than passed through the Suez Canal the year previous. Through the "Soo" Canal at the outlet of Lake Superior there were more than three times as many vessels and nearly a million and three-quarters tons more freight in 1890 than through the Suez Canal during the same year.

There is not the same absolute record of vessels passing through the Detroit River as is obtainable for the two points previously mentioned. But an estimate made by Hon. Geo. H. Ely, of Cleveland, shows that in 1889 there were more than 36,000,000 tons of freight carried through the Detroit River. This sum seems large when it is stated by itself, but the real magnitude will perhaps be better appreciated when it is known that this is 10,000,000 tons in excess of the tonnage at all the seaports of the United States for the same year,

and 3,000,000 tons in excess of the total arrivals and clearances, both coastwise and foreign, of Liverpool and London combined.

The arrivals and clearances of vessels at Chicago for 1890 numbered 21,541, while the corresponding aggregate for New York was but 15,283. The entries and clearances for the entire seaboard of the United States in that year were 37,756, while for the United States ports on the Great Lakes the arrivals and clearances numbered 88,280.

The average cost of transportation on the railroads in the United States for the fiscal year ending June 30, 1891, exceeded nine-tenths (.941) of a cent per ton per mile. The average cost of transportation on the Great Lakes for 1891 was, as near as it can be ascertained, about $\frac{1}{10}$ of a cent per ton per mile. But the importance of the Great Lakes to the business interests of the country may be better understood if these microscopic figures are translated into larger terms.

The traffic of the Great Lakes in 1891 was 27 per cent. of the total traffic of all the railways of the United States for the same year, and if the tonnage carried on the lakes had been carried instead by rail, at the average price per ton per mile above given, it would have cost, in round numbers, $150,000,000 more than was actually paid for its transportation by water. The total expenditure under the river and harbor bills up to date for the improvement of the Great Lakes above Niagara Falls is less than $30,000,000.

So that the saving on the business of a single year has been a more than fivefold return for all the expenditures made in the past. The cost of water transportation decreases so rapidly with each increase in depth of available channel and capacity of the vessels engaged in the carrying trade that the saving effected by the deepening of the connecting channels from sixteen feet to twenty feet will be greater than that which has been produced by the expenditure of the $30,000,000 in the past.—*Review of Reviews.*

WATER.

Chemically and physically considered, water is a most interesting and profitable study, and in the science of engineering it forms a most important factor. It was considered an element until about the end of the eighteenth century, when Preistly discovered that when hydrogen gas was burned in a glass tube, water was deposited on its sides.

The composition of water was first discovered by Cavendish in the year 1781, a claim of the discovery also being made in behalf of James Watt and others. Chemical analysis shows that water is composed of two gases, oxygen and hydrogen, and in its purest state consists of 89 parts of oxygen and 11 parts of hydrogen by weight. The gases unite by bulk in the proportion of two volumes of hydrogen to one volume of oxygen. Hydrogen is the lightest known body in nature, and weighs but one-fifteenth part of its bulk in atmospheric air.

Water can be decomposed into its constituent gases by heat or by electricity, the water being acidulated to make it a conductor of electricity.

The different conditions it can exist in are four, namely: the liquid, the solid, the vaporous and the gaseous.

Its density is greatest at a temperature of 39° F. At that temperature it occupies the least space and weighs the most per cubic foot. Curiously, in cooling from 212° water gradually diminishes in volume until it reaches 39°. From this point it expands as it cools until it reaches 32°, its freezing point, when, if there be no resistance by way of external pressure, or presence of salt, it is suddenly crystalized into ice, accompanied by great expansion, amounting to something like 10 per cent. of its volume. If kept under a pressure to prevent expansion, or if kept in a perfect state of rest it may be cooled to a temperature below its freezing point.

Its solvent properties are greater than that of any other liquid known, and it is due to its absorbent nature that it is never found entirely free from foreign substances in solution;

in fact, water is capable of holding in solution, more or less, all bodies, and, as a rule, more of the body is dissolved when the water is hot than when cold. It is practically incompressible, and owing to its incompressible nature it is made to develop great power in hydraulic machines.

It is a poor conductor of heat, as is clearly shown in firing up a fire-box boiler; the water above the grates may be heated to a temperature due to 100 lbs. of steam, while the water a few inches below still remains cold. Its specific heat or capacity for obsorbing heat is greater than that of any other liquid or solid.

Under ordinary atmospheric pressure, water boils and is converted into steam at a temperature of 212° F. The boiling point depends upon the pressure. In a vacuum, water boils at 98° F. Again, under an absolute pressure of 90 lbs., the boiling point is 320° F. If kept under a sufficient pressure to prevent expansion, water cannot be converted into steam when kept in a high temperature.

A gallon of water (United States standard) weighs 8⅓ lbs., and contains 231 cubic inches. A cubic foot of water weighs 62½ pounds, and contains 1,728 cubic inches, or 7½ gallons.

THE COPPER WIRE in the long distance telephone between New York and Chicago, is said to weigh 435 lbs. to the mile, and the entire weight of wire used for the circuit is 826,500 lbs., for there are two wires. These wires are strung on 42,750 poles, each pole being 35 feet high. It requires no extra paraphernalia to telephone 1,000 miles. The only difference is that for long distance the wire must be heavier.

NEVER be guilty of complaining that your occupation is overcrowded. In no line of human activity is there a crowd except at the tail end. If you lack elbow room, it is because you are a tail-ender. *Don't* be a tail-ender. "Lots of room forward, gents," as they say in the street cars.—*The Roller Mill.*

USEFUL FOR RAPID APPROXIMATION.

Feet multiplied by .00019 equal miles.

Yards multiplied by .0006 equal miles.

Links multiplied by .22 equal yards.

Links multiplied by .66 equal feet.

Feet multiplied by 1.5 equal links.

Square inches multiplied by .007 equal square feet.

Circular inches multiplied by .00546 equal square feet.

Square feet multiplied by .111 equal square yards.

Acres multiplied by 4840 equal square yards.

Square yards multiplied by .0002066 equal acres.

Width in chains multiplied by 8 equal acres per mile.

Cubic feet multiplied by .04 equal cubic yards.

Cubic inches multiplied by .00058 equal cubic feet.

U. S. bushels multiplied by .046 equal cubic yards.

U. S. bushels multiplied by 1.244 equal cubic feet.

U. S. bushels multiplied by 2150.42 equal cubic inches.

Cubic feet multiplied by .8036 equal U. S. bushels.

Cubic inches multiplied by .000466 equal U. S. bushels.

U. S. gallons multiplied by .13368 equal cubic feet.

U. S. gallons multiplied by 231 equal cubic inches.

Cubic feet multiplied by 7.48 equal U. S. gallons.

Cylindrical feet multiplied by 5.878 equal U. S. gallons.

Cubic inches multiplied by .004329 equal U. S. gallons.

Cylindrical inches multiplied by .0034 equal U. S. gallons.

Pounds multiplied by .009 equal cwt. (112 pounds.)

Pounds multiplied by .00045 equal tons (2240 pounds).

Cubic feet of water multiplied by 62.5 equal pounds (avoirdupois).

Cubic inches of water multiplied by .03617 equals pounds (avoirdupois).

Cylindrical feet of water multiplied by 49.1 equal pounds (avoirdupois.)

Cylindrical inches of water multiplied by .02842 equal pounds (avoirdupois).

U. S. gallons of water divided by 13.44 equal cwt. (112 pounds).

U. S. gallons of water divided 268.8 equal tons.

Cubic feet of water divided by 1.8 equal cwt. (112 pounds).

Cubic feet of water divided by 35.88 equal tons.

Cylindrical feet of water multiplied by 5.875 equal U. S. gallons.

Column of water 12 inches high 1 inch in diameter equals 3.4 pounds.

2,200 cylindrical inches equal 1 cubic foot.

SLIP.

The screw propeller, if working in a medium that could not yield, would advance a distance equal to the pitch during each revolution. But such is not the case with the water in which the wheel does actually revolve. Therefore the difference between the distance the screw travels and the actual distance the ship travels, is termed the slip of the screw. *Positive slip* is the slip where the speed of the ship is less than the speed of the screw propeller. *Negative slip*, which rarely if ever occurs, is the slip where the speed of the ship is greater than that of the screw. If the pitch of the screw be multiplied by the number of revolutions made per hour, and that product divided by 5,280, the number of feet in one mile, the quotient will be the distance in miles that the ship would make if there were no slip; deducting the actual distance traveled by the ship, gives the amount of the slip.

Example: A screw having 15 feet pitch making 75 revolutions per minute, drives the ship at the rate of ten miles per hour, what is the slip? $15 \times 75 \times 60 = 67{,}500$ feet traveled by the screw. While the actual distance traveled by the ship has been 10×5280 ft. $= 52{,}800$ ft.; subtracting that sum from the distance traveled by screw, we have $67{,}500 - 52{,}800 = 14{,}700$ ft. Dividing the difference $14{,}700 \div 67{,}500 = 22$ per cent. of slip.

TO SUPERINTENDENTS and ENGINEERS!

Before you buy any boiler compound, inquire who manufactures the best boiler compound to remove scale and keep boilers from scaling and water from foaming in boilers.

THE BELTON BOILER COMPOUND

is considered by all practical engineers one of the first in the market. It has no superior. It is made from nine of the very best chemicals to remove scale and protect the iron. Warranted no acid. Mr. Belton has had 36 years experience in running boilers on the ocean, lakes and rivers; he knows what kind of compound is needed to keep boilers clean. The BELTON BOILER COMPOUND is not made from oak bark and soda, or so-called vegetable solvents, as many others are that claim to keep boilers from scaling. The proof is in testing them. A ship-carpenter can build a ship but he cannot sail her. It requires a practical engineer to know what is needed to keep boilers in good order. Belton's Boiler Compound will entirely prevent incrustation and corrosion; and I boldly claim that whilst it contains no trace of acid or other injurious ingredients, it is the most potent re-agent ever discovered for the complete removal of lime and other impurities from water for steam boilers. It acts by converting the whole of the solids contained in the water into soft sludge, which can easily be blown out, instead of hard scale, which can not.

The formation of scale has a very serious effect upon the steaming quality of the boiler, as scale is one of the best non-conductors of heat known.

Recent tests have shown that "a scale of $\frac{1}{16}$ inch thickness requires 12 per cent. more fuel to produce the same results as are obtained with a clean boiler, while ¼ inch of scale requires 38 per cent."

A good compound will prevent eight of ten boiler explosions. It will keep the water pipe to the water gauge free from scale, so that the engineer and fireman will know that the water in the glass is solid water.

Fuel is the main item in all manufactories run by steam.

FROM THE CHICAGO "ILLUSTRATED CENTURY."

Just now there is no subject being more widely discussed in the columns of scientific and trade journals throughout the country than the comparative merits of the different compounds that are on the market for the removal and prevention of scale, forming in steam boilers.

In a recent issue of this journal in an article on boiler incrustation, we

mentioned at considerable length the merits of the Belton Boiler Compound. Since the publication of that article, the writer has been a witness of the blowing off of one day's deposit of the mineral substance above referred to, at the Bridgeport Pumping Works, where the Belton Compound is used. Notwithstanding the fact that the boilers at this establishment are as clean as a gun-barrel, the discharge of sediment appeared as black and thick as mud. After this black sludge had all been blown off it was followed by perfectly clear water, then by a volume of steam. This is sufficient to justify us in proclaiming the Belton Compound the very best. And as it is purely chemical, it is in no way injurious to the boilers.

USERS OF BELTON'S BOILER COMPOUND.

ILLINOIS STEEL COMPANY, ...	493	BOILERS
DOLESE & SHEPARD, ...	16	"
GRANT LOCOMOTIVE WORKS, ...	8	"
JOLIET WATER WORKS, ...	4	"
DETROIT WATER WORKS, ...	4	"
BRIDGEPORT PUMPING WORKS, ...	12	"
SOUTH CHICAGO SHIP YARD, ...	4	"

AND MANY OTHERS.

STEAMERS ON LAKES.

CITY OF CHICAGO, CITY OF MILWAUKEE,
AND MANY OTHERS.

All orders should be sent to

T. E. BELTON,

981 Clifton Park Avenue, CHICAGO, ILL.
Works in rear of Bridgeport Pumping Works.

P. S.—Sold by the barrel and half-barrel. Delivered to any part of the United States free, on 30 days trial.

ST. JOSEPH, Mich., June 14th, 1892.

MR. THOMAS E. BELTON, Chicago, Ill.

SIR: Will you please address Mr. F. W. Lehnartz, Assistant Engineer, United States Engineer Office, Grand Rapids, Mich., and give him all the information, prices, etc. of your Boiler Compound. It is desired that the Engineer Department get the best scale compound, and you will please state in your letter that I have found yours to be the best recommended by competent engineers here.

Very respectfully,
(SIGNED) LLOYD CLARK, *United States Inspector.*

OFFICE OF MICHIGAN CITY HARBOR IMPROVEMENTS.
(Under direction of United States Engineer Department.)

MICHIGAN CITY, Ind., October 5th, 1892.

T. E. BELTON, ESQ., Chicago, Ill.

DEAR SIR: I have to inform you that the compound purchased of you has been in use on the United States tug "Graham," and given good satisfaction. Our engineer reports, and I have observed personally, that it is a very satisfactory agent in cleansing boilers and preventing incrustation.

Very respectfully, J. A. MANNING, *Superintendent.*

HARVESTING INDIA-RUBBER.

The rubber is not obtained from cultivated orchards, but is taken from the trees which grow wild in low-lying areas or basins. Such areas are a striking feature of the valley of the Amazon. They are not marshes, but are the perfect analogues of the basins existing in the flood plain of the Mississippi. The rubber-trees are found in the greatest abundance along the tributaries and the smaller streams which feed these. At the beginning of the rainy season the long siesta at the *fazenda* comes to an end. If rubber trees exist in sufficient abundance near at hand, the Indians and others, who live in a state of dependency at the *fazenda*, are sent each day into the woods, where they collect the milk and bring it in to be cured; but it often happens that journeys of several days or a week, must be made to procure a plentiful supply.

In this case great canoes, sometimes 40 feet in length, are fitted out with provisions, and arrangements are made for a protracted expedition. No elaborate preparations are made for camping. A blanket and hammock for each of the whites, and a rude covering, consisting of sheets of the fibrous inner bark of a tree for the Indians, several bags of *farinha* and rice, salt fish, and a plentiful store of *cachaca*, or rum of sugar cane, with arms and ammunition, are considered a sufficient equipment. When a site for a camp has been selected the Indians can in half a day construct a palm-thatched hut for their abode, which will prove water tight for a week. The rubber trees being gregarious in habit, one man can tap from 40 to 50 in a day.

The whole party sallies forth in the morning, each provided with a quantity of little tin cups and a narrow-bladed hatchet. An incision, merely penetrating the outer bark, being made with the latter instrument, one of the cups is attached beneath with a bit of moistened clay, into which the thick white milk at once begins to flow. The rubber-gatherer passes from tree to tree until he has consumed half the day, after which he col-

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KEYSTONE MARINE VALVE

These Red Rubber Valves are the best Air and Foot Valves made. If your dealer does not keep them write direct to the factory.

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RUBBER GOODS FOR STEAMER SERVICE.

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Sunshine Sheet Packing,
Steam & Water Sheet Packing,
Gaskets,
Square and Round Packing,
Red Core Round Packing.

Try Our Celebrated Sutton Ring and Spiral Packing

The best Piston and Valve Stem Packing made.

lects the milk from all the trees he has tapped. This is taken to the camp where it is "smoked." Were the milk allowed to stand for a period of 24 hours or longer, it would thicken into a coarse, granular, somewhat stringy mass, which produces a very inferior grade of manufactured rubber. The coarse material, known in Brazil as *sernamby*, is often found hanging in great bunches upon the trees, where it has oozed through a crack in the bark, or from the end of a fractured limb. If, however, the milk be poured over a wooden blade or round stick, and held for a few moments in the dense fumes from a fire of certain palm nuts, it is coagulated into the finely elastic rubber with which all are familiar.

A second coating of milk is poured over the blade and similiarly treated, until the successive layers have made a ball of considerable size. In some sections the habit is to make the balls or *pelles* from 18 inches to two feet in diameter, a practice which results in imperfections in the "smoking," and retards the subsequent drying of the rubber. Defects may readily occur in this curing process by making the successive additions of milk too thick, or as a result of inequalities in the exposure of various parts of the ball to the smoke. Such deterioration is easily discoverable by cutting the ball in half, when it will reveal itself by a vesicular or granular condition of the rubber, the occurence of which reduces the whole lump to the middle grade (*entra fina*) between the "fine Para" and the "coarse" or *sernamby*.

The nuts, which according to native experience, yield uniformly the best results, are those from the well-known palm *Inajá*. This does not usually grow in great abundance in the neighborhood of the *Heveas*, so that the nuts of the palm *Urucury* are frequently substituted, and failing an adequate supply of these, resort is had to the nuts of the palm known as *Uauassú* (pronounced *wah wahs-soo*). The rubber after being "smoked" is still white, only becoming black by prolonged exposure to the air. It has, however, acquired its characteristic elasticity, and an odor exactly similar to that of

smoked hams. The smoke from other nuts, or from a simple wood fire, will not produce the desired result.

So far as I have been able to ascertain no thorough chemical investigation has been made to identify the volatile ingredient which accomplishes this remarkable physical change in the rubber, which, previous to curing, is present in the sap as an emulsion. A study of this phenomenon might lead to important modifications of the present treatment, for if means could be found to cure the rubber of the *Heveas* by the addition of some liquid or powder to the milk it would not only prevent entirely the formation of a middle grade, but would enable the rubber to be prepared in a better form for shipment, affording an enormous saving to all concerned.

At the end of the harvest, if such a term be allowable, the canoes laden with gum, return to the *fazenda*, and then follow merry-makings, prone to end in a wild debauch. The careful creditor now looks out for the reward of his indulgence, commonly making his round of visits in a steam launch, capable of carrying from 10 to 50 tons of rubber. After his collections are finished he forwards the product to Manaos or Para, where it is boxed for final shipment to the United States and Europe.—*Harper's Weekly.*

The "monkey wrench" is not so named because it is a handy thing to monkey with, or for any kindred reason. "Monkey" is not its name at all, but "Moncky." Charles Moncky, the inventor of it, sold his patent for $2,000, and invested the money in a house in Williamsburg, Kings County, N. Y., where he now resides.

VASELINE for lubricating commutators has no equal. It will not gum between the brushes. It is also an excellent preparation for removing dirt from the hands. Rub the hands with a small amount and wash with warm water and soap. It leaves the hands clean and soft.

LAKE TONNAGE.

The books of the United States Treasury Department contain the names of 3,600 vessels, measuring 1,154,870.38 tons in the lake trade. In classification of this fleet, the lakes have more steamboats of 1,000 to 2,500 tons than the combined ownership of this class of vessels in all other sections of the country. The number of vessels of 1,000 to 2,500 tons on the lakes on June 30th, 1891, was 310, and their aggregate gross tonnage 512,787.58; in all other parts of the country the number of this class of vessels was, on the same date, 213 and their gross tonnage 319,750.84. The classification of the entire lake fleet is as follows:

Class.	Number.	Tonnage.
Steam vessels,	1,592	756,751.53
Sailing vessels,	1,243	325,131.06
Canal boats,	703	72,515.42
Barges,	62	20,472.37
Total,	3,600	1,154,870.38

Tonnage built on the lakes during the past five years, according to the reports of the United States commissioner of navigation, is as follows:

	No of Boats.	Net Tonnage.
1887,	152	56,488.32
1888,	222	101,102.87
1889,	225	107,080.30
1890,	218	108,515.00
1891,	204	111,856.45
Total,	1,021	485,042.94

St. Mary's Falls and Suez Canal traffic: Number of boats through St. Mary's Falls canal in 1890, 228 days of navigation, 10,557; tonnage, net registered, 8,454,435. Number of boats through Suez Canal during 1890, full year, 3,389; tonnage, net registered, 6,890,014. Number of boats through St. Mary's Falls canal in 1891, 225 days of navigation, 10,191; tonnage, net registered, 8,400,685. Number of boats through the Suez Canal during 1891, full year, 4,207; tonnage, net registered, 8,698,777.—*Marine Review.*

EDWARD C. GREENOUGH. PHILIP TUMMELTY.

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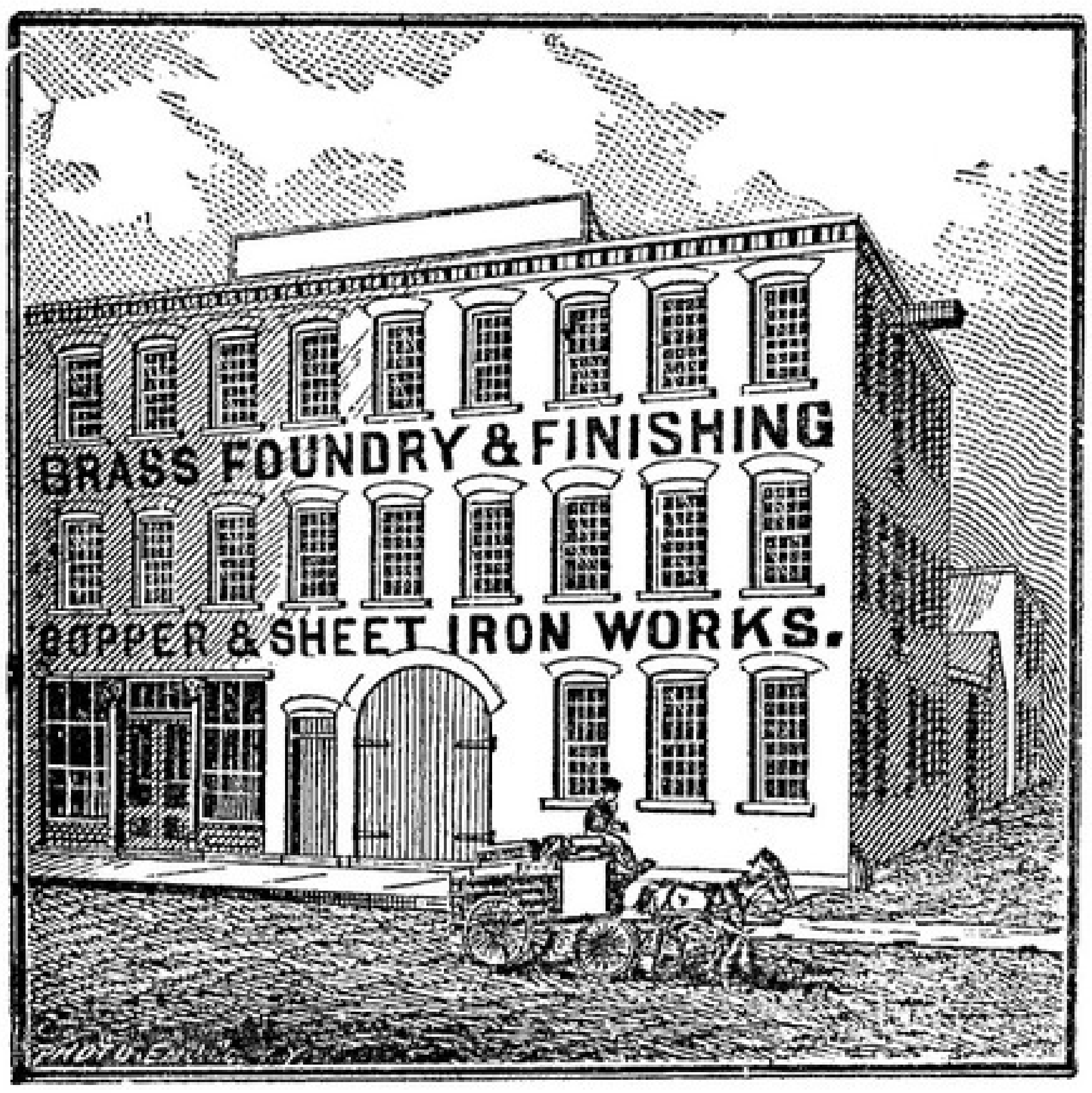
Successors to A. H. BROWN.

Machine Shop and Brass Foundry



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DOPE CUPS AND DEADLIGHTS A SPECIALTY.

Job Work Promptly Attended to. Satisfaction Guaranteed.

LOSS BY UNCOVERED STEAM PIPES.

A practical test to ascertain the loss of heat from uncov-steam pipes, and those covered, was conducted several years ago by Messrs. Upson, Supt., and Chief Engineer Itree, of the Hartford Carpet Co. The result of the test as published in *The Locomotive* at the time were as follows:

A room having an even temperature, free from draughts or air currents was selected close to the boilers, where steam could be taken from the top of the main pipe free from water or condensation. A suitable vessel was arranged to catch this water, connected to 120 running feet of two-inch steam pipe. A short section of the pipe was enclosed in a box, with a glass in the side for the purpose of reading the rise of temperature indicated by a thermometer placed therein. Steam was first blown through the pipe and receiver until both were free from water caused by heating the pipe and receiver. The valve was then closed and ten-hour trials made, the water carefully collected and weighed, with the following results:

FIRST TRIAL.

TEN HOURS, 120 FEET OF 2-INCH PIPE, UNCOVERED.

Average steam pressure, ...	79 pounds
Average temperature of room, ...	70 degrees
Average temperature of box, ...	167 degrees
Pounds of water condensed, ...	826 pounds

SECOND TRIAL.

TEN HOURS, 120 FEET OF 2-INCH PIPE COVERED WITH ASBESTOS, HAIR, FELT AND PAPER.

Average steam pressure, ...	77 pounds
Average temperature of room, ...	69 degrees
Average temperature of box, ...	80 degrees
Pounds of water condensed, ...	222 pounds

THIRD TRIAL.

TEN HOURS, 120 FEET OF 2-INCH PIPE COVERED WITH PLASTIC MATERIAL.

Average steam pressure, ...	80 pounds
Average temperature of room, ...	70 degrees
Average temperature of box, ...	107 degrees
Pounds of water condensed, ...	480 pounds

It is obvious that there must be twice as much heat in two pounds of boiling water as there is in one pound, but a thermometer put into a vessel containing one pound, and then into another vessel containing two pounds, will still give the same indication, viz., 212°. Now, different bodies have different capacitics for heat—their specific heat varies. That is to say, if we bring two different bodies to the same temperature, the quantity of heat in each will vary. Water has the highest specific heat of any known substance, gas or liquid, and is therefore taken as a standard. The following table gives the specific heat of a few well-known metals, water being taken as unity :

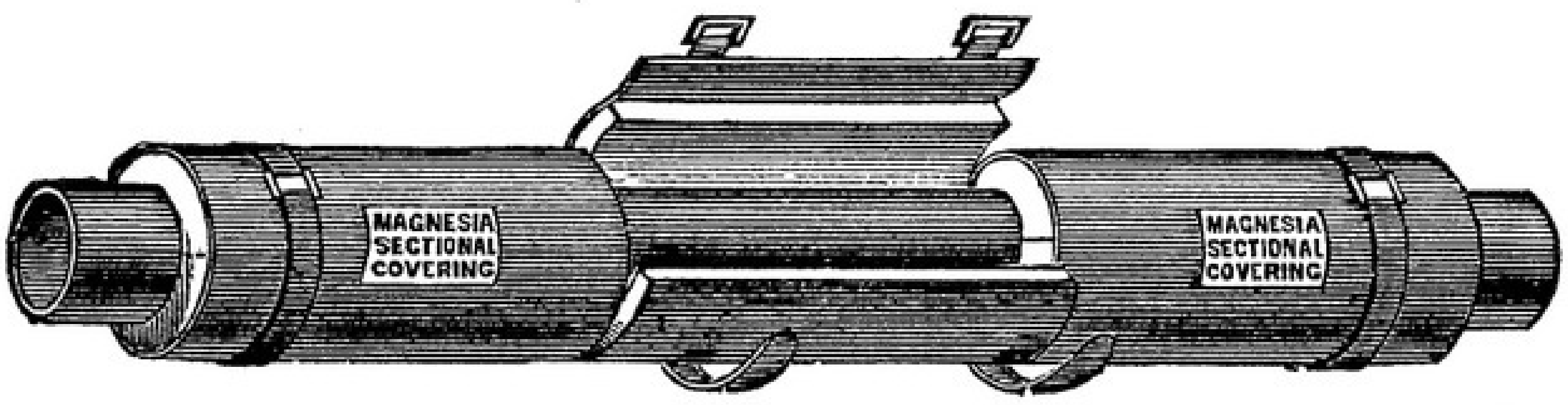
Lead	.03084
Gold	.03244
Mercury	.03332
Tin	.05695
Silver	.05701
Copper	.09515
Zinc	.09555
Wrought-iron	.01218
Steel	.11650
Cast-iron	.12983

To find the quantity of heat necessary to raise any of these metals to a given temperature, it is only necessary to multiply the quantity of heat required to raise an equal weight of water to the same temperature by the fraction given above. Thus, for example, let it be required to ascertain the quantity of heat necessary to raise, say, 10 lbs. of cast-iron 100°. We know that the quantity of heat required to raise 10 lbs. of water 100° is $10 \times 100 = 1000$ thermal units. Then $1000 \times .12983 = 129.83$ thermal units. In round numbers, the specific heat of water is about eight times as great as that of cast-iron.

Gasses have in like manner their specific heats. The specific heat varies with the pressure under certain conditions, but with this we have at present nothing to do.

Nor need we concern ourselves with the specific heat of

MAGNESIA



FOR WROUGHT IRON PIPE,
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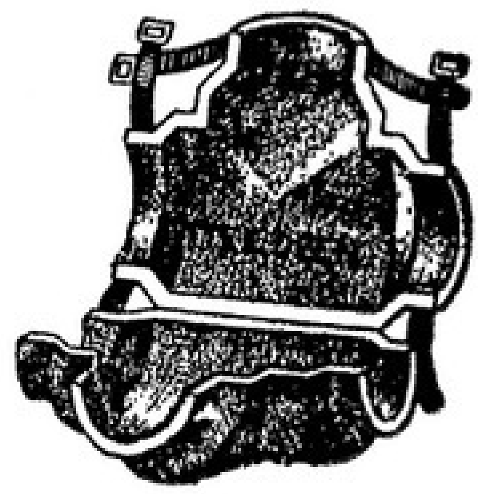

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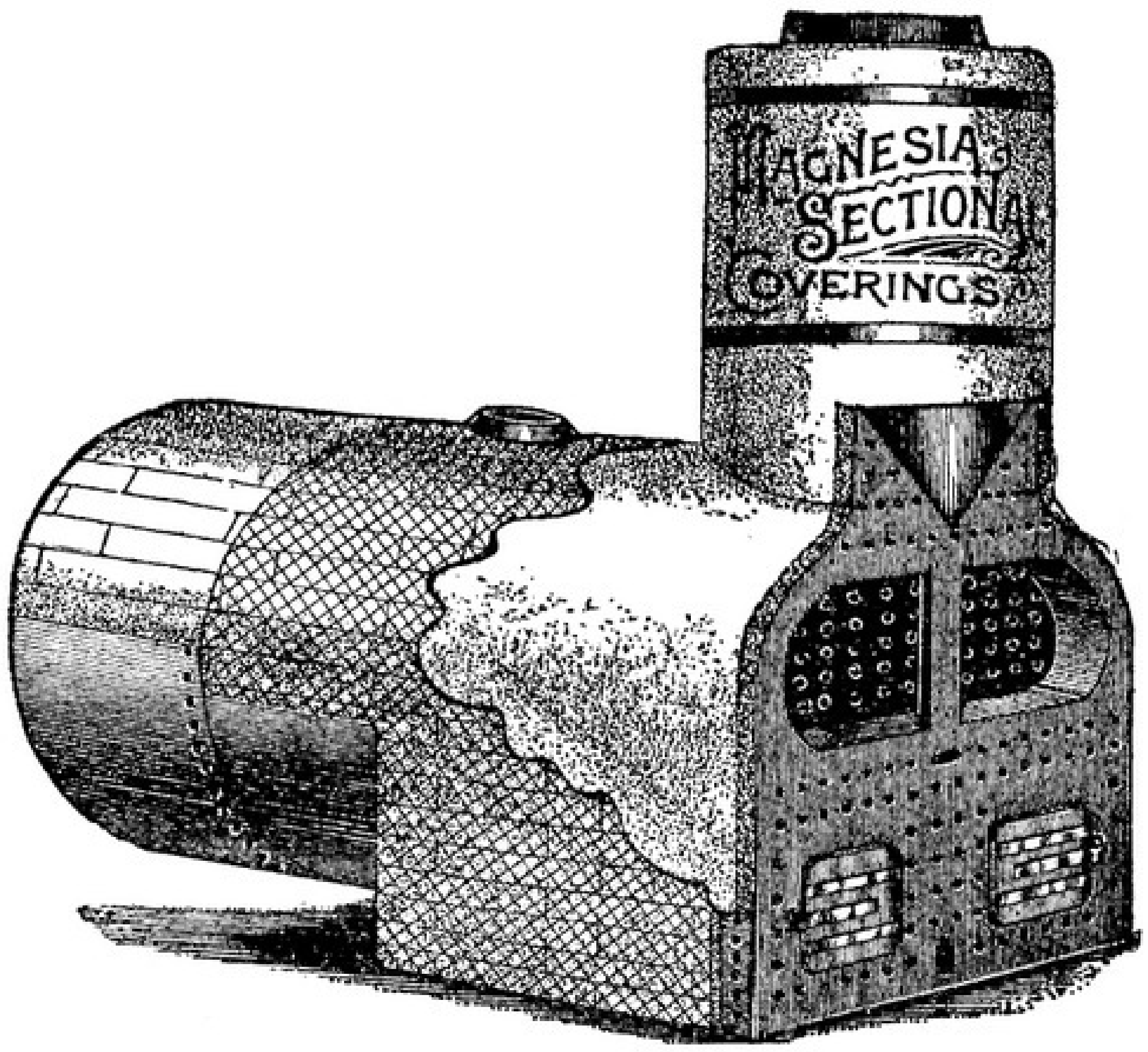

"White Squadron's" Boilers
Are Covered with Magnesia.
MOST OF THE

ROBERT A. KEASBEY,

58 Warren Street,
NEW YORK.

119 Franklin Street,
BUFFALO.

any gas but air, which is .23. In round numbers, 1 lb. of water requires four times as great a quantity of heat to raise it to a given temperature as does a pound of air.

A pound of coal, properly burned, will give out about 14,500 thermal units, and requires for its combustion 18 lbs. to 24 lbs. of air. The first effect of the burning coal on the grate is to raise this air to a very high temperature; but as the air passes through the tubes or flues of the boiler, it surrenders a large quantity of this heat. We may, therefore, neglect the furnace temperature and deal only with that of the gasses as they leave the boiler. A very common temperature is 500°. If the air entered at 60°, then it is clear that going to the chimney at 500°, it has been raised by the coal through 440°. The total quantity of heat wasted up the chimney per pound of coal will be found by multiplying the number of pounds of air admitted to the furnace per pound of coal by the elevation in temperature, and by the fraction .23 representing the specific heat of air. We have then, for 18 lbs. of air, $18 \times 440 \times .23 = 1821.6$, and if 24 lbs. of air are admitted we have $24 \times 440 \times .23 = 2428.8$. From this it will be seen that the more air we admit to the furnace the greater the waste; but care must be taken not to admit too little, otherwise there will be still greater waste caused by the imperfect burning of the coal.

Of the 14,500 thermal units given out by the coal, then, we see that about 2,000 are wasted up the chimney unavoidably, leaving us only 12,500 to make steam with. It is to save some of this waste heat that "economizers" are employed; these are pipes set in an enlargement of the flues, and through them the cold feed water is pumped, and so raised in temperature. The object of all economical boilers is to send away the escaping gases at as low a temperature as possible, but this can never be less than that of the water in the boiler.

We have now to consider the work done by the 12,500 units remaining to us in generating steam. The first work is

to raise the feed water to the boiling point, which varies with the pressure, increasing as the pressure increases. The following table gives a few of the more usual pressures and temperatures:

ABSOLUTE PRESSURE PER SQ. IN. LBS.	TEMPERATURE. DEG. FAH.
14.7	212
20	228
30	250
40	267
50	281
60	293
70	303
80	312
90	320
100	328
150	358
200	382
250	401

The safety valve loads will always be 14.7 lbs.—in round number, 15 lbs.—less than these, because the pressure of the atmosphere loads the valve. Thus 100 lbs. in the preceding table corresponds with a pressure as shown by the pressure gauge of 85 lbs. The feed water goes on rising in temperature till it attains the temperature proper to the pressure. Then it begins to boil, not before. Let us suppose, for the sake of illustration, that we have a boiler working at 85 lbs. by the gauge; the boiling point is 328°. Let the feed be pumped in at 60°; then each pound of it will require 328—60=268 thermal units to raise it to the boiling point. Once this is reached the water gets no hotter. The heat is thenceforth expended, not in augmenting temperature, but in making steam, and is said to become "latent," or hidden. This expression is not strictly correct, but as it is commonly used it may be allowed to pass. Thus, then, each pound of steam contains what may be regarded as two quantities of heat — one quantity expended in raising temperature, the other in converting the water into steam. Now it is a noteworthy fact that the sum of the sensible and latent heats of steam is very nearly constant under all circumstances. Thus,

Dear Sir:

Are you troubled with LEAKY VALVES?

Do you know that in the "ROY" we have a Valve that will alleviate your sufferings?

Have you seen it? If not, would you like to? If you are too busy to call at our place, drop us a card and we will call on you.

Have you a good Flue Cleaner? We sell the "WILSON" which we consider the best in the market.

Are you suited with your Engine Packing? We handle the "SIMS ELASTIC." To try it, will insure us a customer.

We also sell Mechanical Books (Roper's at 20% off). Do you wish to subscribe for the "Power", "Stationary Engineer", or any other journal of a kindred nature? If so, remember we are,

Yours truly,

ENGINEER SUPPLY CO.

13 Chapin Block.

let us take steam at atmospheric pressure, as, for example, it comes from the spout of a tea kettle; its sensible temperature is 212°, representing 212 thermal units per pound. Its latent heat is 965°, representing 965 thermal units per pound, and 212+965=1177 thermal units per pound, measured from zero. Steam 100 lbs. pressure (85 lbs. by the gauge) has a sensible temperature of 328°, representing 328 thermal units, a latent heat of 883 thermal units, and 328+883=1211, measured from zero, which, it will be seen, is only 34° in excess of the sum of the latent and sensible heats of steam at 212°. The total number of units of heat which have to be used in making a pound of steam will vary with the temperature of the feed water. Let that be 60°. Then each pound of steam at 100 lbs. pressure represents 1211—60 =1151 thermal units. We have seen that all the heat left in, after the air necessary for combustion has had its share, is 12,500 units per pound of coal. Then $\frac{12{,}500}{1151}=10.86$ lbs. as the greatest possible weight of water that can be converted into steam of 100 lbs. absolute pressure; if the admission of air is at the rate of about 22 lbs. of air per pound of coal, and if the temperature of the escaping gasses is 500°. With the data here given our readers can calculate for themselves the return to be expected under other conditions of pressure, temperature, weight of air admitted, and so on.

There are other sources of waste, concerning which we have said nothing. One is that coal is not all combustible. It contains a greater or less weight of ash, and varies greatly in quantity. Another source of waste is bad firing, which causes unburned coal to fall through the bars. Lastly a great deal of heat is radiated from the boiler and the brick work in which it is set. It is to prevent this loss that boilers are clothed. It does take place, however, and in some cases represents a good deal. When all these things are put together it will be seen that large deductions must be made from the total quantity of heat set free by combustion, and a boiler which can evaporate 10.8 lbs. of water from feed at

60° must be exceptionally excellent. What we have said indicates that economy is to be sought, first, in securing the complete combustion of the fuel and the gasses it liberates; secondly, in admitting the smallest quantity of air which will suffice to secure perfect combustion; thirdly, in sending away the gasses from the boiler at a temperature as near as possible to that of the water in the boiler; fourthly, in using the gasses, after they have left the boiler, to heat the feed water; fifthly, to prevent in every way possible the radiation of heat from the boiler; and lastly, we may point out that considerable advantage might be derived from heating the air required for combustion before it enters the furnace, if only it could be done cheaply and in a satisfactory way. The effect of heating it would be analogous to that product by heating feed water, and may be calculated in the same way. —*London Engineer.*

HORSE POWER OF BOILERS.

Strictly speaking, there is no such thing as "horse power" to a steam boiler; it is a measure applicable only to dynamic effect. But as boilers are necessary to drive steam engines, the same measure applied to steam engines has come to be universally applied to the boiler, and cannot well be discarded. In consequence, however, of the different quantity of steam necessary to produce a horse power, with different engines, there has been great need of an accepted standard by which the amount of boiler required to provide steam for a commercial horse-power may be determined.

This standard, as fixed by Watt, was one cubic foot of water evaporated per hour from 212° for each horse power. This was, at that time, the requirement of the best engine in use. At the present time, Prof. Thurston estimates that the water required per hour per horse power, in good engines, is equal to the constant 200, divided by the square root of the pressure, and that in the best engines this constant is as low

as 150. This would give for good engines working with 64 lbs. pressure, 25 lbs. water, and for the best engines working with 100 lbs., only 15 lbs. water per hourly horse power.

The extensive series of experiments, made under the direction of C. E. Emery, M. E., at the Novelty Works, in 1866-8, and published by Prof. Trowbridge, show that at ordinary pressures, and with good proportions, non-condensing engines of from 20 to 300 horse power, required only from 25 to 30 lbs. of water per hourly horse power, in regular practice.

The standard, therefore, adopted by the judges at the late Centennial Exhibition, of 30 lbs. water per hour, evaporated, at 70 lbs. pressure, from 100°, for each horse power, is a fair one for both boilers and engines, and has been favorably received by the American Society of Mechanical Engineers and by steam users, but as the same boiler may be made to do more or less work with greater or less economy, it should also be required that the rating of a boiler be based on the amount of water it will evaporate at a high economical rate.

For purposes of economy, the amount of heating surface should never be less than one, and generally not more than two, square feet for each 5,000 British thermal units to be absorbed per hour, though this depends somewhat on the character and location of such surface. The range given above is believed to be sufficient to allow for the different conditions in practice, though a far greater range is frequently employed. As, for instance, in torpedo boats, where everything is sacrificed to lightness and power, the heating surface is sometimes made to absorb 12,000 to 15,000 B. T. U. per square foot per hour, while in some mills, where the proprietor and his advisers have gone on the principal that "too much is just enough," a square foot is only required to absorb 1,000 units or less per hour. Neither extreme is good economy.

Square feet of heating surface is no criterion as between different styles of boilers—a square foot under some circum-

stances being many times as efficient as in others; but when an average rate of evaporation per square foot for any given boiler has been fixed upon by experiment, there is no more convenient way of rating the power of others of the same style. The following table gives an approximate list of square feet of heating surface per horse power in different styles or boilers, and various other data for comparison:

Type of Boiler.	Square feet of Heating Surface for One H. P.	Coal per sq. ft. H.S. per hour.	Relative Economy.	Relative Rapidity of Steaming.	Authority.
Water-tube	10 to 12	.3	1.00	1.00	Isherwood
Tubular	14 to 18	.25	.91	.50	"
Flue	8 to 12	.4	.79	.25	Prof. Trowbridge.
Plain Cylinder	6 to 10	.5	.69	.20	
Locomotive	12 to 16	.275	.85	.55	
Vertical Tubular	15 to 20	.25	.80	.60	

A horse power in a steam engine or other prime mover, is 550 lbs. raised 1 foot per second, or 33,000 lbs. 1 foot per minute. [From the book "*Steam*," issued by the Babcock & Wilcox Water Tube Boiler Co., by whose permission we print it.]

CONDENSATION.

The latent heat in different vapors varies greatly, the latent heat of steam being greater than that of any other vapor, as is very evident from the fact that it requires five and one-half times as much heat to convert a given quantity, say one pound, of water into steam, as it does to heat the same quantity of water from 32° to the boiling point, 212°. The heat so absorbed is termed latent heat, and is not measurable by the thermometer. Now, if by the application of cold water, the steam be reconverted into water from which it was formed, it would part with its latent heat, and the pound weight of steam would heat five and one-half pounds of cold water to a temperature of 212°.

OBJECTS OF ENGINEERS' SOCIETIES.

An engineers' association which meets only for the purposes of gossip and personal intercourse does not fill the ends required of it, and confers no advantages on members which are worth paying for. Our idea is that an engineers' association should have skeleton working models of the valve gears in general use to-day, including the common slide valve and the link motion. These gears should be so constructed that they can be cast loose, disarranged and purposely set wrong, so that the evil effects of mal-adjustment could be seen. Besides these, various other valves—steam and water—in use should be represented, and the whole outfit and belongings of a modern steam plant, so far as is practicable, should be a part of the association's outfit. When these are obtained the next step is to familiarize the members with them, and to this end competent persons should explain at each meeting the uses of the several gears, and the modifications of which they are susceptible. It is not difficult in large cities to find such persons, but it is not always possible in small towns to find engineers of wide experience who are well versed in their profession, and know how to put their knowledge into an intelligible address of short duration. Moreover, it is not always possible to find men who can explain principles, or, failing to comprehend a principle, know where to look for an explanation of it in works on natural philosophy—or physics, as it is now called. There can be no question, however, of the utility of such an association, and of the vast influence it can exert on any steam-using community it may be located in. They would also—the members would—be much better able to judge of the value of mechanical appliances offered to their employers, and could say whether they would be economical or the reverse. There are some engineers' associations which fully cover the ground named by us, but there also others which neglect the essentials, and spend their evening sessions in reading a

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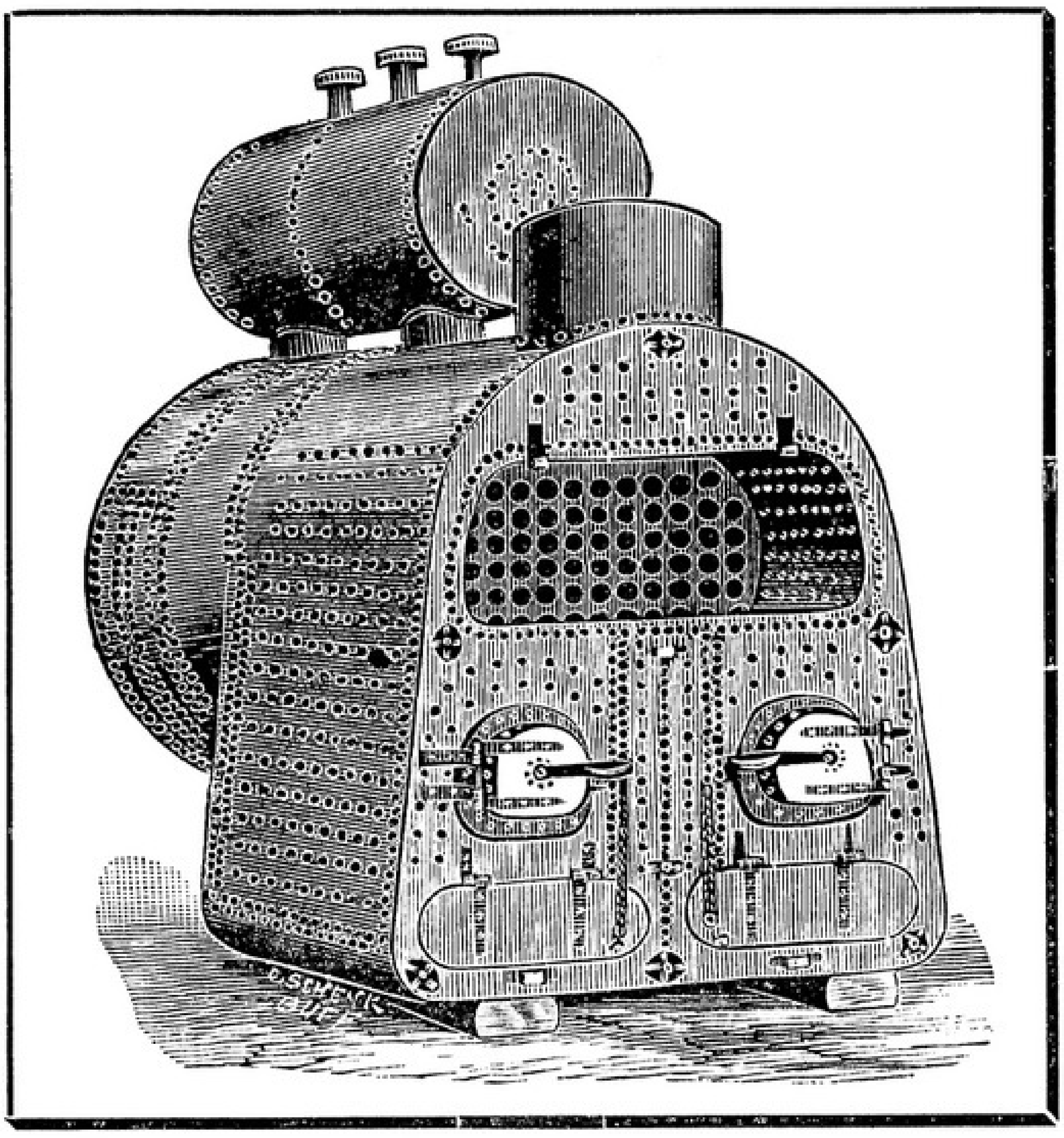

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formal manual of initiation, which is droned out in a tedious way, and interests no one. Such associations have no legitimate places, and their tenure of existence is exceedingly uncertain. We urge all engineers to form societies for mutual improvement, and to inquire into the details of their calling, for it is by mutual interchange that all gain. No one loses anything by giving a brother member information that he can use with profit. The informant's position is just as secure as before he parted with his experience.

The gist of this matter is plain enough. The world moves, and steam users are daily more and more alive to the necessity of economizing wherever it is possible. Good men, that is, engineers who can and do reason, and show savings as the result and proof of their practice, are in greater demand for good places than engineers who merely keep the machine going. There is no committee of steam users with a brass band and a riot act in the next street ready to excommunicate the incompetent engineer, but it is a significant fact that most of the large apartment and office buildings in this city have engineers to whom high salaries are paid solely for their ability.—[*Egbert P. Watson, in the "Engineer," N. Y.*

MELTING POINTS OF SOLIDS. — Taken from Randine's *Manual of the Steam Engine.*

Mercury,	—38°	Copper,	2,548°
Ice,	+32°	Gold,	2,590°
Sulphur,	228°	Nickel,	2,732°
Tin,	426°	Cast Iron,	3,479°
Bismuth,	493°	Tin 3, Lead 5, Bismuth 8	210°
Lead,	630°	Tin 4, Lead 1, Bismuth 5	246°
Zinc,	700°	Tin 1, Bismuth 1,	286°
Silver,	1,280°	Tin 3, Lead 2,	334°
Brass,	1,896°	Tin 2, Bismuth 1,	334°

ANTHRACITE COAL, broken, a cubic foot averages 54 pounds, and a ton, loose, occupies from 40 to 43 cubic feet. Bituminous coal, broken, a cubic foot averages 49 pounds, and a ton loose, occupies 43 to 48 cubic feet.

ELECTRICAL.

The important part that electricity plays in the industrial and commercial affairs of the world at the present time, and the prospects for its future are so great, that this work would be incomplete did we not devote some space to it. At the present time electricity depends upon steam engineering for its generation. Therefore it behooves every live engineer to acquire all the knowledge regarding its generation and application that he possibly can. At the present time nearly all our ocean, river and pleasure steamers are equipped with dynamos for electric lighting, and the engineer who does not acquire knowledge necessary to care for the dynamo and its appliances will find hard work to procure a good position. Engineers will find herein the electrical terms so clearly defined that any person can easily understand them.

First—Volt, unit of pressure, called electro-motor force; same as pounds of steam.

Second—Ampere, unit of quantity, called current; same as gallons of water.

Third—Ohm, unit of resistance; similar to friction.

Fourth—Watt, unit of energy consumed; similar to foot pounds. Seven hundred and forty-six watts equal one horse power; same as 33,000 foot pounds.

The whole question of electrical distribution may be popularly illustrated by its analogy to hydraulics. The dynamo is essentially a rotary pump, but pumping electricity instead of water. If the discharge pipe of a rotary pump be carried around through a given circuit and connected with the suction, both pump and pipes being full of water, the movement of the pump will obviously cause the water to flow in one direction, producing a continuous current of water. Substitute dynamo for pump, wire for pipe and electricity for water, and conception of electrical transmission by the continuous current is at once clear as to its elementary phenomena. We

will bracket the analogous electrical terms; then we may say that a certain number of pounds [volts] of pressure are required to overcome the friction [resistance] of the pipe [wire] in order that the water [current] may flow at the rate of so many gallons [amperes] per minute. The larger the pipe [wire] the more water [current] can be carried and the less will be the friction [resistance]; or, per contra, the smaller the pipe [wire] the less the quantity [amperes] per minute and the greater the friction [resistance]. Manifestly the pipe [wire] might be so small that the friction [resistance] would absorb a very large proportion of the power of the pump [dynamo] leaving but little remaining for useful effect; therefore, the two horns of the dilemma are: if the pipe [wire] be too large it will cost too much; if too small, the loss will be too great.

The electrical appliances are also analagous to engineering appliances. The switches are valves, the fusible strips are the safety-valves, the contacts are the pipe fittings. If the contact is insufficient to carry the current there will be a leak [drop] in the current.

The volt meter is the pressure gauge; the ammeter is the same as the water or gas meter—the recorder of quantity consumed.

Cleanliness is one of the secrets of success in running dynamo electrical machines. If dust, oil and grit are allowed to accumulate, short circuits are formed and consequent heating and undue friction [resistance] and thereby loss of current [power]. Keep your dynamo and its surroundings clean; keep your commutator smooth; keep the spaces between the segments of your commutator clear from copper dust; keep your brushes neatly trimmed, and in fact keep everything as it should be, clean and in order. Dynamos are very sensitive creatures and will not stand neglect, or they will rebel at once.

One cause of trouble in the running of electric light plants is the grounding of armatures. This is sometimes caused by

oil working in, around and between the wires on the pulley end of the armature. The oil softens the insulation, the heat carbonizes it, and the current jumps from one wire to another and short circuits the armature. There is a flash, and unless the machine is stopped at once the armature will be "burned."

When this occurs, after stopping the machine, take your magnet, (if you have one), place the wire from one pole on the armature shaft, the wire from the other pole upon the segments of the commutator. Turn the crank of magneto, and try each segment of commutator; when you get a ring on magneto bell you have found the wire where the trouble is. Then, if it is on the outside where you can get at it to wrap the wires with insulating tape you can repair it yourself. If this can be done, after doing it, test it with the magneto as before, and if you get no ring then you can go ahead again; but if you cannot repair it yourself, the only way is to take the armature out and have it rewound.

Eternal vigilance is the price of safety in the care of electric light plants. One great source of loss of electrical energy is poor contacts. Wherever there is a poor contact there is a leak of current, and like a leaky joint in a steam or water pipe the loss must be made up from the source of supply. Go over your cut-out boxes frequently and try your contacts, and keep them tight. Incandescent lamps are expensive, and a careless engineer can put his employer to great expense in lamps by neglect. Lamps are composed of delicate substances, and will not stand abuse. The carbon filament is very delicate, and they are made to stand a certain voltage [pressure] to produce the given candle power; if this voltage is allowed to increase above what the lamp is calculated to stand, you put the straw on the camel which breaks his back. To increase the voltage on lamps five volts above what they are rated at will shorten the life of the lamp 25 per cent.; it does not require much mathematics to show what this costs the consumer.

WHAT A DYNAMO IS.

A DESCRIPTION OF THE MAIN PRINCIPLE OF AN ELECTRICAL MACHINE.

The collection of electricity, or its generation, as it is often called, is no more or less mysterious than the generation of heat. For those who make no pretensions to understand the governing principles underlying the generation of electricity by a dynamo, we present the following brief explanation, which we hope may be easily grasped:

Perhaps every reader has played with a common horseshoe magnet. No one can have one on his hand, even for a few moments, without noticing that the small piece at the two ends, called the armature, when brought close to these ends, not being allowed to touch them, is affected by some invisible influence which tends to draw it towards these ends. This mysterious influence is called magnetism.

On laying a horseshoe magnet on a piece of paper placed in a horizontal plane and loosely sprinkling iron filings around these ends it can be seen that there is an apparent current of this influence projecting into space from the ends and running across the space at the open ends of the magnet. These imaginary projections or currents of this mysterious influence are called "lines of magnetic force." Here we have the magnetic force, and the next thing is to get the electricity. By moving an armature across these lines of magnetic force at the ends of a magnet we find it requires an expenditure of energy. In the case of a dynamo we obtain this energy from steam, water power or some other source. The generation of electricity is as easily understood as the method of getting power by a steam engine. It is known that if we take a conductor of electricity, like a common copper wire, and by any means cause it to move through lines of magnetic force in a certain direction, that electricity will be developed in this

conductor. No one pretends to explain why. This is the whole mystery of the dynamo, with all its astonishing possibilities in the service of man.

We know how to do it, but are as much in mystery about the reason Nature acts in this way as we are to explain why an apple goes down instead of up when rolled from your open hand.

A dynamo consists principally of two parts, one of which is a large mass of soft cast or wrought iron called the magnet, and the other part is called the armature. Soft iron does not remain permanently as a magnet except to a very slight degree. However, some magnetism always remains stored up in the iron. There is a germ of magnetism great enough to be easily and quickly increased when properly handled by well known methods. The revolving shaft, as seen in the ordinary dynamo, is called the armature. The armature is usually constructed by having hundreds of insulated copper wires in it, and is made to revolve at a high velocity by some mechanical force, such as steam. Suppose this speed is 1,000 revolutions per minute, which is not unusual, and that we have 500 wires on this armature, then we will have, as the armature revolves, what would be equivalent to a single wire cutting across all the lines of magnetic force 500,000 times each minute.

The magnet generally surrounds the armature, and these magnetic lines of force are shooting through the armature in a continuous stream at an inconceivable velocity. All the wire conductors on the revolving armature, as they move through these lines of magnetic force, are constantly picking up their little share of electricity and unloading it by means of ingenious mechanical devices connecting with the conducting wire that leads from the dynamo, and receiving the returning electricity on another wire leading back into the dynamo.

One of Nature's wonderfully mysterious laws causes soft iron to become magnetic when surrounded by a current of elec-

tricity. In the ordinary dynamo this law is of the greatest utility. As the electrical current is being collected by the revolving armature it is led around the magnet, and thus the magnetic germ is quickly changed into a mighty force, again feeding the armature which transforms it from magnetic to electrical force.—*Mechanical and Electrical Progress.*

HOW TO MANAGE A DYNAMO PLANT.

BY THOMAS R. TALTAVALL, MEMBER INSTITUTE ELECTRICAL ENGINEERS.

Editor of the *Electrical Age,* New York.

In view of the rapidly extending use of electric lights on steam vessels, some general instructions for the management of electric light plants will not be amiss.

Some people imagine that a dynamo will keep on generating current without much attention until it is worn out, but this is a great mistake. A dynamo needs at least as much attention as a steam engine or other like piece of mechanism, if not more, because it is really more delicate in its construction. If properly and intelligently looked after, however, very little or no trouble need ever be experienced.

Be sure that your machine is thoroughly clean in all its parts, and all screws and bolts are in place and tight. Dirt and grease around a dynamo are very detrimental to good service. Loose parts, such as screws, nuts, etc., always cause trouble by causing imperfect joints, and this means waste of energy and consequent deficiency of light current. Screws and bolts will become loose on dynamos by the constant vibration when the machine is in operation, therefore these parts must be carefully watched.

No metal dust should be permitted to settle on the commutator, as such substance will sooner or later cause a short circuit or a burn-out. The commutator and brushes must be kept scrupulously clean. No foreign substance, such as dust, etc., should be allowed to get in between the brushes and the

commutator. The commutator is the most delicate part of a dynamo and should receive extraordinary care.

The machine should be brought up to speed gradually, all the parts being watched closely so as to shut down instantly in case any trouble is developed.

The custom is to lift the brushes from the commutator when the dynamo is not in use. When the dynamo is brought to full speed, the brushes are lowered into contact with the commutator, and adjusted so as to avoid sparking. The brushes may, however, be adjusted before the machine is started.

It is not necessary to remind the dynamo tender that it is essential to have all the bearings of the dynamo properly lubricated at all times.

Never lift a brush from the commutator when the dynamo is running, as it causes excessive sparking and burns the commutator.

Stopping a dynamo must be done gradually, as it is started, and the brushes, if they are carbon, must not be lifted from the commutator until the armature has stopped. If the brushes are copper they should be lifted just before the armature stops so as to avoid catching in the commutator in case the armature should run back a little, as sometimes happens. With carbon brushes, however, this danger does not exist.

The manner of starting and stopping dynamos in individual cases is usually taught the engineer who is to have regular charge of the machinery, by the electrical engineer who had charge of installing the plant. Only general rules for the management of such machines can be given here. With these, however, and the exercise of judgment, rules applicable to individual plants can easily be worked out.

Dynamos, like the human system, are liable to disorders; and, as a rule, the causes thereof can be diagnosed by the symptoms exhibited in the behavior of the machine. The ordinary troubles may be classified under three general heads, viz.: 1, heating of the armature; 2, heating of the field

magnets; 3, sparking at the commutator. Heating of the bearings might also be included in this list; but, as this is a mechanical irregularity, it is assumed that every engineer can tell when this condition of things exists, and how and what remedy to apply.

We will consider briefly the ordinary causes of the troubles above enumerated, and what remedies to apply to overcome them. Heat is one of the greatest enemies of the dynamo. If any of the parts get so hot as to be unbearable to the hand then the safe limit has been passed, and unless the heat is reduced in some way the machine will be in danger of becoming injured. Excessive heat in the armature or field magnet coils is dangerous because it injures the insulation of the wire, and damage to the insulation means a short circuit or burn-out. Every precaution, therefore, must be taken to keep the heat of the parts as low as possible. The maximum safe limit to which the heat of the parts may rise is 72° or 75° F. above the temperature of the surrounding air. The application of the hand to the parts liable to become heated is a reliable test of the condition of such parts.

Heating of the armature may be caused by, 1, excessive current in the coils; 2, short-circuited coils; 3, moisture in or about the insulation of the coils. The remedy for case 1 is to reduce the load, or the magnetic strength of the field. In case 2, short circuits are frequently caused by metallic dust or solder on the commutator bars or their connections. This trouble is easily remedied by the removal of substances. If this is not the cause the coil will have to be rewound.

When moisture exists in the armature coils, they feel moist or steam when running and get hot. The remedy is to dry the armature in a warm but not hot place.

Heating of the field magnets may be caused by too much current in the field coils, or moisture. The former condition shows itself by the magnet coils becoming unbearably hot to the hand. The fault may be due to a short circuit in which case the remedy lies in removing the fault by

strengthening the insulation, or rewinding. Moisture in the coils shows itself as it does when it exists in the armature coils, viz., steams and gets moist, and the remedy is to dry the coils in a warm place.

As regards the heating of bearings as has already been stated, it is assumed that the engineer or dynamo tender is already conversant with the several causes thereof, and the remedy to apply in each individual case, therefore instructions in this particular line would be superfluous here.

In a brief article of this character, it is manifestly impossible to cover all of the ills that a dynamo is heir to; not that a dynamo is any more liable to derangement that any other piece of mechanism, but owing to the impossibility of giving rules that will apply to every possible contingency. The general list of troubles given above is a serviceable one; and if any trouble should develop, the remedy for which none of the rules given provides, it is likely, that some one of them will at least suggest a cure which with the exercise of proper judgment, can be properly and effectually applied. To fully cover the ground would require a good sized volume. However, for the information of those who may desire to go deeper into the interesting subject it may not be out of place here to mention an excellent little book brought out recently by Crocker & Wheeler of New York, entitled, "*Practical Management of Dynamos and Motors.*" The book can be obtained of the *Electrical Age Publishing Co.*, World Building, New York. Price, $1.00; and to those who have charge of small electric light plants it will be found of great value.

As the writer was requested to limit this article and make it as comprehensive as possible, he trusts that his efforts will in a measure answer the purpose he set out to accomplish, and hopes that one at least may receive some benefit therefrom.

MULTIPLY 37 by 3, by 6, by 9, by 12, 15, 18, etc., and note the result.

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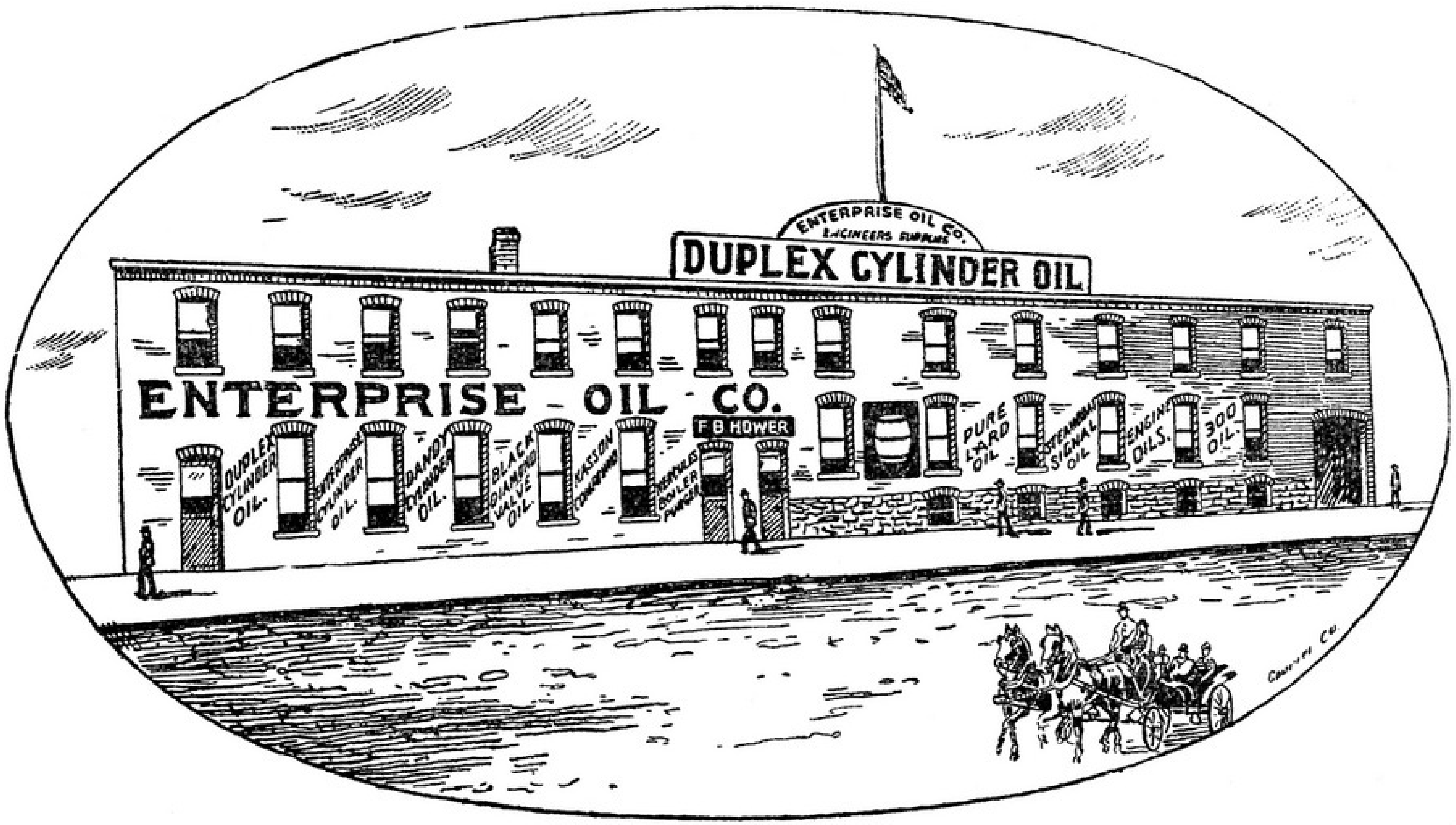

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TO FIND THE SIZE OF A PULLEY.

To find the size of driving pulley: Multiply the diameter of the driven by the number of revolutions it shall make, and divide the product by the revolutions of the driver. The quotient will be the size of the driver.

FORMULA.

$$\text{Size of driving pulley} = \frac{\text{Diameter of driven x rev. of driven}}{\text{rev. of driver.}}$$

The diameter and revolutions of the driver being given, to find the diameter of the driven that shall make a given number of revolutions:

Multiply the diameter of the driver by its number of revolutions, and divide the product by the number of revolutions of the driven. The quotient will be the size of the driven.

FORMULA.

$$\text{Size of driven pulley} = \frac{\text{Diameter of driver x rev. of driver}}{\text{rev. of driven.}}$$

To find number of revolutions of the driven pulley: Multiply the diameter of the driver by its number of revolutions, and divide by diameter of driven. The quotient will be the number of the revolutions of the driven.

FORMULA.

$$\text{Revolution of driven pulley} = \frac{\text{Diameter of driver x rev. of driver}}{\text{diameter of driven.}}$$

DRIVING WITH COUNTER-SHAFT.

For example, a machine having a pulley 12 inches in diameter is to be driven from a line shaft carrying a pulley 30 inches in diameter, through a counter-shaft on which the driven pulley is 25 inches in diameter, and the driver 18 inches, how many turns per minute will the machine make, supposing the line shaft makes 100.

$100 \times 30 \div 25 = 120$ turns for counter-shaft, and the machine will make $120 \times 18 \div 12 = 180$ turns, belt slip not

being taken into consideration. An engine making 225 turns per minute, is to drive a dynamo at the rate of 1,250 turns, the pulley on the dynamo being 16 inches, what must be the diameter of driving pulley on engine shaft, making no allowance for slip? 225:1250:16: the size required, $1250 \times 16 \div 225 = 88.8$ inches the size required.

WATER IN STEAM PIPES.

From a very valuable article on "Heating Cities by Steam," by Charles E. Emery, Ph. D., in the *Franklin Institute Journal*, we make the following extract, knowing that it will be found of interest to engineers, showing, as it does, the cause of "water rams":

The principal cause of the accidents in the operation of large, long steam pipes, underground or otherwise, arises from collections of water in the mains, when the pipes are cold or there is no steam circulating. * * *

If steam be admitted at the top of a vessel partly filled with cold water, condensation will take place until the surface is somewhat heated, and this, in connection with a cloud which forms above the surface, will retard rapid condensation, so that in due time the full steam pressure can be maintained above water cold at the bottom. This phenomenon is not an infrequent occurrence in boilers in which the circulation is defective. It is therefore perfectly safe to heat up any vessel containing cold water if the steam can be admitted from the top upon the surface of the water, and so maintained. If, however, steam be blown in below the surface of the water a bubble will be formed, which will increase in size until its surface becomes sufficiently extended to condense the steam more rapidly than it can enter, when a partial vacuum will be created, the bubble will collapse, and the water—flowing in from all sides at high velocity—will meet with a blow, forming what is called a water ram. In blowing

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a small quantity of steam into a large quantity of water, these explosions occur in the middle of the mass, and create simply a series of sharp noises. If, however, steam be blown into a large incline pipe full of water, it will rise by difference of gravity to the top of the pipe, forming a bubble as previously stated, and when condensation takes place, the water below the bubble will rush up to fill the vacuum, giving a blow directly against the side of the pipe. As the water still further recedes, the bubble will get larger, and move farther and farther up the pipe, the blow each time increasing in intensity, for the reason that the steam has passed a larger mass of water, which is forced forward by the incoming steam to fill the vacuum.

The maximum effect generally takes place at a "dead end," as it is called, or where the end of the pipe is closed. Even if the water does not originally extend to the "dead end," if the pipe near it be once filled with steam which has bubbled through water on its way to that point, there may be sufficient cold metal to condense it, so that collapse will take place on the same principles as before, and the whole mass of water in the pipe be driven by the incoming current against the end, sometimes with tremendous force, the effect being to cause leaks and sometimes rupture the pipe or break out the end connections. It is not necessary, either, that the end of the pipe be closed. In fact, under certain conditions, a more forcible blow is struck when the end of the pipe is open, as for instance, when a pipe crowned upward is filled with water, one end being open and the steam introduced at the other, a bubble will in due time be formed at the top of crown, when the water will be forced in by atmospheric pressure from one end, and by steam pressure from the other, and the meeting of the two columns frequently ruptures the pipe. Evidently, too, the same action can occur without difficulty in a level pipe, but, as previously stated, cannot in a pipe which descends away from the entering steam, so that the latter is *always above* the water.

TABLE OF PROPERTIES OF SATURATED STEAM.

PARTLY FROM C. H. PEABODY'S TABLES.

Pressure in pounds per sq. in. above vacuum.	Temperature in degrees Fahrenheit.	Total heat in heat units from water at 32 degrees.	Heat in liquid from 32 degrees in units.	Heat of vaporization, or latent heat in heat units.	Density or weight of cubic feet in lbs.	Volume of one lb. in cubic feet.	Factor of equivalent evaporation at 212 degrees.	Total pressure above vacuum.
1	101.99	1113.1	70.0	1043.0	0.00299	334.5	.9661	1
2	126.27	1120.5	94.4	1026.1	0 00576	173.6	.9738	2
3	141.62	1125.1	109.8	1015.3	0.00844	118.5	.9786	3
4	153.09	1128.6	121.4	1007.2	0.01107	90.33	.9822	4
5	162.34	1131.5	130.7	1000.8	0.01366	73.21	.9852	5
6	170.14	1133.8	138.6	995.2	0.01622	61.65	.9876	6
7	176.90	1135.9	145.4	990.5	0.01874	53.39	.9897	7
8	182.92	1137.7	151.5	986.2	0.02125	47.06	.9916	8
9	188.33	1139.4	156.9	982.5	0.02374	42.12	.9934	9
10	193.25	1140.9	161.9	979.0	0.02621	38.15	.9949	10
15	213.03	1146.9	181.8	965.1	0.03826	26.14	1.0003	15
20	227.95	1151.5	196.9	954.6	0.05023	19.91	1.0051	20
25	240.04	1155.1	209.1	946.0	0.06199	16.13	1.0099	25
30	250.27	1158.3	219.4	938.9	0.07360	13.59	1.0129	30
35	259.19	1161.0	228.4	932.6	0.08508	11.75	1.0157	35
40	267.13	1163.4	236.4	927.0	0.09644	10.37	1.0182	40
45	274.29	1165.6	243.6	922.0	0.1077	9.285	1.0205	45
50	280.85	1167.6	250.2	917.4	0.1188	8.418	1.0225	50
55	286.89	1169.4	256.3	913.1	0.1299	7.698	1.0245	55
60	292.51	1171.2	261.9	909.3	0.1409	7.097	1.0263	60
65	297.77	1172.7	267.2	905.5	0.1519	6.583	1.0280	65
70	302.71	1174.3	272.2	902.1	0.1628	6.143	1.0295	70
75	307.38	1175.7	276.9	898.8	0.1736	5.760	1.0309	75
80	311.80	1177.0	281.4	895.6	0.1843	5.426	1.0323	80
85	316.02	1178.3	285.8	892.5	0.1951	5.126	1.0337	85
90	320.04	1179.6	290.0	889.6	0.2058	4.859	1.0350	90
95	323.89	1180.7	294.0	886.7	0.2165	4.619	1.0362	95
100	327.58	1181.9	297.9	884.0	0.2271	4.403	1.0374	100
105	331.13	1182.9	301.6	881.3	0.2378	4.205	1.0385	105
110	334.56	1184.0	305.2	878.8	0.2484	4.026	1.0396	110
115	337.86	1185.0	308.7	876.3	0.2589	3.862	1.0406	115
120	341.05	1186.0	312.0	874.0	0.2695	3.711	1.0416	120
125	344.13	1186.9	315.2	871.7	0.2800	3.571	1.0426	125
130	347.12	1187.8	318.4	869.4	0.2904	3.444	1.0435	130
140	352.85	1189.5	324.4	865.1	0.3113	3.212	1.0453	140
150	358.26	1191.2	330.0	861.2	0.3321	3.011	1.0470	150
160	363.40	1192.8	335.4	857.4	0.3530	2.833	1.0486	160
170	368.29	1194.3	340.5	853.8	0.3737	2.676	1.0502	170
180	372.97	1195.7	345.4	850.3	0.3945	2.535	1.0517	180
190	377.44	1197.1	350.1	847.0	0.4153	2.408	1.0531	190
200	381.73	1198.4	354.6	843.8	0.4359	2.294	1.0545	200
225	391.79	1201.4	365.1	836.3	0.4876	2.051	1.0576	225
250	400.99	1204.2	374.7	829.5	0.5393	1.854	1.0605	250
275	409.50	1206.8	383.6	823.2	0.5913	1.691	1.0632	275
300	417.42	1209.3	391.9	817.4	0.644	1.553	1.0657	300
325	424.82	1211.5	399.6	811.9	0.696	1.437	1.0680	325
350	431.90	1213.7	406.9	806.8	0.748	1.337	1.0703	350
375	438.40	1215.7	414.2	801.5	0.800	1.250	1.0724	375
400	445.15	1217.7	421.4	796.3	0.853	1.172	1.0745	400
500	466.57	1224.2	444.3	779.9	1.065	.939	1.0812	500

The gauge pressure is about 15 pounds (14.7) less than the

total pressure, so that in using this table, 15 must be added to the pressure as given by the steam gauge. The column of Temperatures gives the thermometric temperature of steam and the boiling point at each pressure. The "factor of equivalent evaporation" shows the proportionate cost in heat or fuel of producing steam at the given pressure as compared with atmospheric pressure.

To ascertain the equivalent evaporation at any pressure, multiply the given evaporation by the factor of its pressure, and divide the product by the factor of the desired pressure.

Each degree of difference in temperature of feed-water makes a difference of .00104 in the amount of evaporation. Hence, to ascertain the equivalent evaporation from any other temperature of feed than 212°, add to the factor given as many times .00104 as the temperature of feed-water is degrees below 212°. For other pressures than those given in the table, it will be practically correct to take the proportion of the difference between the nearest pressures given in the table.—From "*Steam.*"

AREAS AND DIAMETERS OF GRATES, ETC.

The following table is intended to give the areas in square inches and in square feet, of circles of various diameters in feet and decimals of a foot; and also to give the equivalents in lineal inches of the diameters in feet. It will be found particularly handy in steam engine, pump, and boiler work.

To get the second column, or areas in square feet, the squares of the diameters in feet in the first columns are multiplied by 0.7854.

To get the fourth column, or equivalents in inches of the diameters in feet as given in the first column, the figures in the first column are multiplied by 12.

To get the third column or areas in square inches, either the numbers in the second column are multiplied by 144, or

the squares of the figures in the fourth column are multiplied by 0.7854.

Thus $0.25 \times 0.25 \times 0.7854 = 0.04909$; $0.25 \times 12 = 3$; $3 \times 3 \times 0.7854 = 7.0686$, or practically 7.069 or 7.07.

The areas are given to two decimal places, not because that degree of accuracy would be required in practice in designing grates, but to make the same table serviceable in other work requiring more exactness.

DIAM. FEET.	AREA SQ. FEET.	AREA SQ. INCHES.	DIAM. INCHES.	DIAM. FEET.	AREA SQ. FEET.	AREA INCHES.	DIA. IN.
.25	.04969	7.069	3.	3.	7.0686	1017.87	36
.30	.07009	10.178	3.6	3.25	8.2958	1194.59	39
.33	.08769	12.56	4.	3.5	9.6211	1385.44	42
.40	.12537	18.085	4.8	3.75	11.045	1590.43	45
.50	.19675	28.27	6.	4.	12.566	1809.55	48
.60	.28244	40.712	7.2	4.25	14.186	2042.82	51
.66	.34982	50.26	8.	4.5	15.904	2290.21	54
.7	.38475	55.42	8.4	4.75	17.721	2551.75	57
.75	.44109	63.62	9.	5.	19.635	2807.43	60
.8	.50267	72.38	9.6	5.50	23.758	3421.18	66
.9	.63617	91.61	10.8	6.00	28.274	4071.50	72
1.00	.78540	113.09	12.	6.5	33.183	4778.36	78
1.25	1.2272	173.71	15.	7.	38.475	5541.77	84
1.5	1.7671	254.46	18.	7.50	44.179	6361.72	90
1.75	2.4053	346.36	21.	8.0	50.265	7238.23	96
2.	3.1416	452.38	24.	8.50	56.745	8171.30	102
2.25	3.9761	572.55	27.	9.	63.617	9160.90	108
2.5	4.9087	706.85	30.	9.5	70.882	10207.05	114
2.75	5.9396	853.29	33.	10.	78.540	11309.76	120

SOMETHING WORTH KNOWING.

A cement for iron which will stand even so severe a test as the blows of a steam hammer, can be made by mixing equal parts of sulphur and white lead with about one-sixth proportion of borax. This powder should be wetted with sulphuric acid and applied in a thin layer between the two surfaces of metal to be connected, which should then be pressed tightly together. The cement will dry in two or three days, when the joint will be found to be perfect.

THE STEAM PUMP.

The idea entertained by many engineers, that water is raised by suction is erroneous, as properly speaking, there is no such principle as suction. Water or other liquids are raised through a tube or hose by the pressure of the atmosphere on their surface. When the atmosphere is removed from the tube, there will be no resistance to prevent the water from rising, as the water outside the pipe, still having the pressure of the atmosphere upon its surface, forces water up into the pipe, supplying the place of the excluded air, while the water inside the pipe will rise above the level of that outside of it proportionally to the extent to which it is relieved of the pressure of the air. If the first stroke of a pump reduces the pressure of the air contained in the pipe from 15 pounds on the square inch to 14 pounds, the water will be forced up the pipe to the distance of about 2¼ feet, since a column of water an inch square and 2¼ feet high is equal in weight to about one pound. Now, if the second stroke of the pump reduces the pressure of the atmosphere in the pipe to 13 pounds per inch, the water will rise another 2¼ feet; this rule is uniform, and shows that the rise of the column of water within the pipe is equal in weight to the pressure of the air upon the surface of the water without.

The distance that a pump will lift or draw water, as it is termed, is about 33 feet, because water of 1 inch area 33 feet weighs 14.7 pounds; but pumps must be in good order to lift 33 feet, and all pipes must be air-tight. Pumps will give better satisfaction lifting from 22 to 25 feet.

No pump, however good, will lift hot water, because as soon as the air is expelled from the barrel of the pump the vapor occupies the space, destroys the vacuum, and interferes with the supply of water. As a result of all this the pump knocks. When it becomes necessary to pump hot water, the pump should be placed below the supply, so that the water may flow into the valve chamber. The most necessary con-

dition to the satisfactory working of the steam pump is a full and steady supply of water. The pipe connection should, in no case, be smaller than the openings in the pump. The suction, lift and delivery pipes should be as straight and smooth on the inside as possible.

The area of the steam and exhaust pipes should in all cases be fully as large as the nipples in the pump to which they are attached.

SAFETY VALVE RULES.

RULE 1.—Multiply the square of the diameter of the valve by .7854. This will give area of valve in square inches. Multiply this product by the pressure in pounds per square inch. From this subtract the *effective* weight of lever, valve and stem. Now multiply by the distance from valve to fulcrum and divide the product by the distance from fulcrum to weight. The quotient will be the required weight in pounds.

Example—What weight will be required on the end of the lever of a safety valve of the following dimensions? Diameter of valve, $4\frac{1}{2}$ inches; distance from valve to fulcrum, 3 inches; distance from fulcrum to weight, 24 inches; steam pressure, 30 lbs.; effective weight of lever, 8 lbs.; and weight of valve, stem and pin, 10 lbs. $4.5 \times 4.5 \times 7854 = 15.9043 \times 60 = 954.25 - 18 = 936.25 \times 3 = 2808.75 \div 24 = 117$, the weight required.

RULE 2.—For determining the length of lever of a safety valve: Multiply the total effective pressure on valve as found by Rule 1, and subtract from it the weight of lever, valve, stem and pit. Multiply the remainder by distance from valve to fulcrum, and divide by the weight. The quotient will be the distance required from fulcrum to weight.

Applying the rule to the preceding example, we have as total effective pressure 954 pounds, and $954 - 18 = 936 \times 3 = 2808 \div 117 = 24$ inches, the distance from weight to fulcrum.

RULE 3.—Required, the pressure necessary to raise a valve: Multiply the distance from weight to fulcrum by the weight,

and divide the product by the distance from the valve to fulcrum. To the quotient add the weight of the valve, stem and pin; the sum will be the total pressure on the valve. Divide the total pressure by the area of valve; the quotient will be the pressure in pounds per square inch required.

Applying rule to above example, we have $24 \times 117 = 2808 \div 3 = 936 + 18 = 954 \div 15.9 = 60$ pounds, the pressure required.

SPRING LOADED SAFETY VALVES.

The English Board of Trade rules, give the following formula for determining the size of steel of which the spring is to be made.

$$\sqrt[3]{\frac{S \times D}{C}} = d$$

Where—

S = the pressure on valve in pounds;
D = the diameter of spring from center to center of wire in inches;
d = the diameter or side of square steel in inches;
C = constant 8000 for round steel and 11,000 for square steel.

Example: Required the size of square steel. Valve 4-inch diameter, pressure 75 pounds, mean diameter of spring 3 inches. The pressure on a 4-inch valve, at 75 pounds per square inch, is 942 pounds. Substituting known values, we have:

$$\sqrt[3]{\frac{942 \times 3}{11{,}000}} = .63, \text{ or } 942 \times 3 = 2826.0 \div 11{,}000 = .2569.$$

The cube root of .2569 is .63, the size of steel required according to formula.

To FIND the side of the greatest square that can be inscribed in a given circle: Take .7 of the diameter and increase the product by 1 per cent. of itself. Example: What is the largest square that can be cut from a 23″ circle?

$$\begin{array}{rl} & 23 \times .7 = 16.1 \\ \text{1 per cent. of } 16.1 = & .161 \\ \hline \text{Ans.} & 16.261 \text{ inches.} \end{array}$$

HEATING FEED WATER.

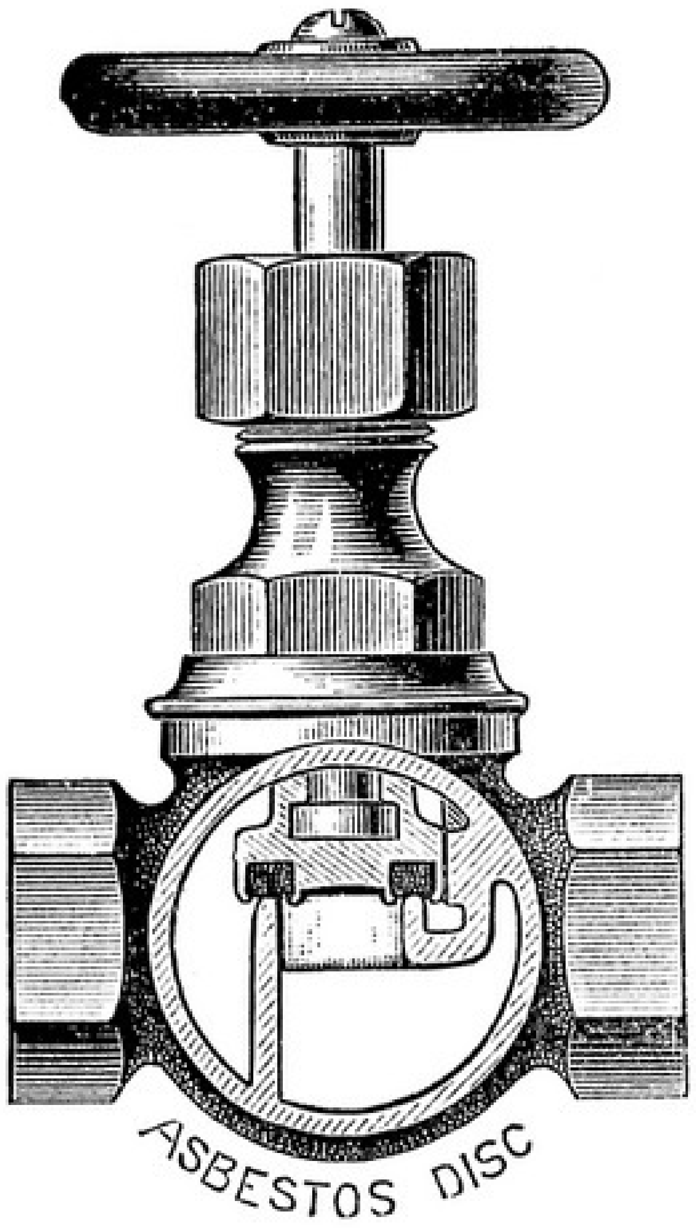
The percentage of saving of fuel, by utilizing part of the heat in exhaust steam for heating feed water, is found by subtracting the temperature of the water as it enters the heater from the temperature of the water as it leaves the heater, and divide the remainder by the total heat of the steam in the boiler. The quotient will be the percentage of saving. For example: Water enters the heater at 50° F., and is taken from the heater at 210° F., the pressure in the boiler being 90 pounds. Referring to the table "Properties of Steam," we find that at 90 pounds gauge pressure, the total heat in steam from zero is 1215°. Therefore 210—50=160, the number of degrees of heat imparted by exhaust. 160÷1215=13¼ per cent. saving of fuel—a rate of saving at which a good heater would soon pay for itself. It is not alone the saving of coal that should be considered, but the saving of repairs on the boiler, made necessary by the excessive contraction caused by pumping cold water into the boiler.

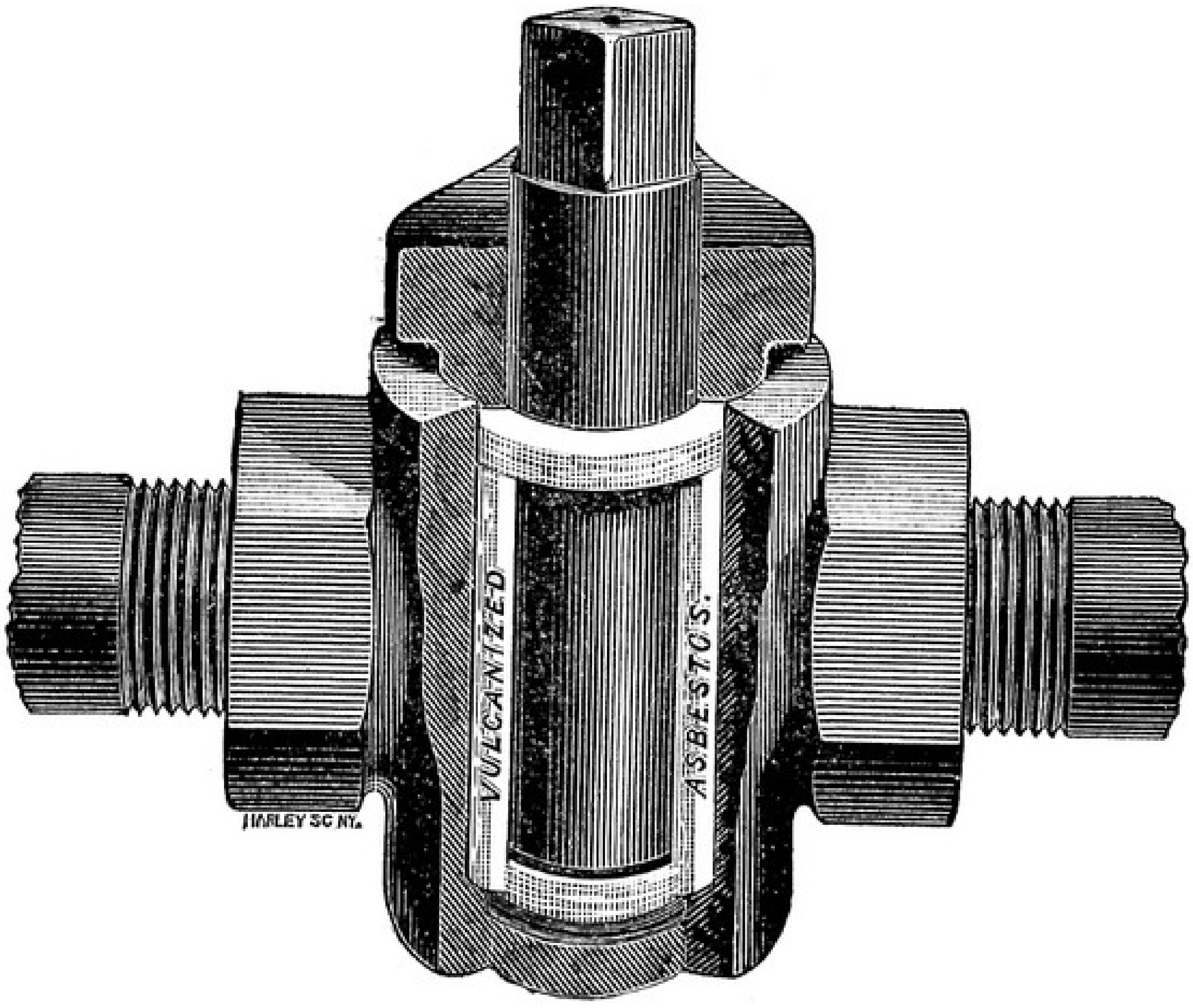
HOW ICE IS FORMED.

By means of two thermometers, it is first ascertained that the temperature of the water at the surface and at the bottom is respectively 48 and 45 degrees. A cold wind sweeps over the surface of the water, so that the temperature is speedily reduced to, say 44 degrees. By this reduction in temperature, it contracts and becomes specifically heavier, sinking and displacing the comparatively light and warm water below, which rises to the surface, becomes cooled below 44 degrees and immediately falls, displacing the warmer water at the bottom, which in turn rises, gets cool and falls, its place being again supplied by lighter and warmer water. And so the cooling and sinking processes go on, the upper thermometer always indicating the higher temperature, when suddenly the magic point, 39 degrees is reached, when all movement at once ceases. The upper layer of water is still exposed to the cooling influence of the wind, and speedily falls in temperature, but still retains its place. The upper thermometer now shows that the water which surrounds it is being rapidly reduced in temperature, but the lower one remains stationary at 39 degrees. At this temperature water is heavier than at any other, and there, like a stone, it remains at the bottom, and it is fully protected from outward influences by the mass of superincumbent water, its temperature remains very much at the same point. The water on the top, however, having nothing to protect it, gets cooler and lighter every moment. Down the theremometer goes to 37, 35 and 32 degrees, and then a slight breeze ripples the surface and the next moment a thin sheet of ice spreads itself over all. The ice, however, is colder and lighter than the water, so that it floats on the surface and acts as a blanket, protecting the comparatively warm and heavy water below from being cooled. So that even during the severest winter only a comparatively thin superficial layer of ice is usually formed, and the greater part of the water remains unfrozen at the bottom.

THE FAIRBANKS CO.

STEAM SPECIALTIES.





CUT AWAY VIEW OF THE ASBESTOS PACKED COCK.

BRASS Globe and Angle Valves, Asbestos Disc; Brass Radiator Valves, Asbestos Disc; Brass Safety Valves, Asbestos Disc; Brass Hose Valves, Asbestos Disc; Brass Swinging Check Valves, Brass Locomotive Check Valves, Brass Back Pressure Valves, Brass Swinging Stop Valves, Brass Swinging Lock Check Valves. . . . .

BRASS Cocks, Asbestos Packed; Brass Cocks, Asbestos, Packed, for Hose; Brass Cocks, Asbestos Packed, for Locomotive Blow-Offs; Brass Gauge Cocks, Asbestos Packed; Brass Gauge Cocks, Asbestos Disc; Brass Gate Valves, Asbestos Seat; Brass, Asbestos Packed, Water Gauges. . . . .

IRON Body Globe and Angle Valves, Asbestos Disc; Iron Body Cross Valves, Asbestos Disc; Iron Body Safety Valves, Asbestos Disc; Iron Body Swinging Check Valves, Iron Body Swinging Back Pressure Valves, Iron Body Swinging Stop Valves, Iron Body Swinging Lock Check Valves, Iron Body Gate Valves, Asbestos Seat. . . . .

IRON Cocks, Asbestos Packed, Screwed and Flanged; Iron Cocks, Asbestos Packed, for Hose; Iron Cocks, Asbestos Packed, for Superheated Steam; Iron Cocks, Asbestos Packed, for Ammonia; Iron Cocks, Asbestos Packed, with Stop and Waste; Iron Cocks, Asbestos Packed, Three-Way. . . . .

IRON Cocks, Asbestos Packed, Special Patterns; All Iron Ammonia Gauges, Asbestos Packed; Pratt's Patent Return Steam Trap, Vulcabeston Sheet Packing, for Steam, etc.; Vulcanized Asbestos Rope Packing, Hancock Inspirators, Stationary and Locomotive Pattern.

THE FAIRBANKS CO.,

210 and 212 Main St., BUFFALO, N. Y.

AREAS OF CIRCLES IN SQUARE INCHES.

Diam. in inches.	Area in sq. inches.	Diam. in inches.	Area in sq. inches.	Diam. in inches.	Area in sq. inches.
1-16	.0030	22½	397.61	54	2290.64
⅛	.0122	23	415.48	54½	2332.83
3-16	.0276	23½	433.74	55	2375.83
⅜	.1104	24	452.39	55½	2419.23
7-16	.1503	24½	471.44	56	2463.01
½	.1963	25	490.87	56½	2507.19
9-16	.2485	25½	510.71	57	2551.76
⅝	.3068	26	530.93	57½	2596.72
11-16	.3712	26½	551.55	58	2642.08
¾	.4417	27	572.56	58½	2687.83
13-16	.5185	27½	593.96	59	2733.97
⅞	.6013	28	615.75	59½	2780.51
15-16	.6903	28½	637.94	60	2827.44
1	.7854	29	660.52	60½	2874.76
1 1-16	.8861	29½	683.49	61	2922.47
1⅛	.9940	30	706.86	61½	2970.57
1 3-16	1.107	30½	730.62	62	3019.07
1¼	1.227	31	754.77	62½	3067.96
1 5-16	1.353	31½	779.31	63	3117.25
1⅜	1.484	32	804.25	63½	3166.92
1 7-16	1.622	32½	829.58	64	3217.00
1½	1.767	33	855.30	64½	3267.46
2	3.141	33½	881.41	65	3318.31
2½	4.908	34	907.92	65½	3369.56
3	7.068	34½	934.82	66	3421.20
3½	9.621	35	962.11	66½	3473.25
4	12.566	35½	989.80	67	3525.66
4½	15.904	36	1017.88	67½	3578.47
5	19.635	36½	1046.35	68	3631.69
5½	23.758	37	1075.21	68½	3685.29
6	28.274	37½	1104.47	69	3739.28
6½	33.183	38	1134.12	69½	3793.67
7	38.485	38½	1164.16	70	3848.46
7½	44.179	39	1194.59	71	3959.20
8	50.266	39½	1225.42	72	4071.51
8½	56.745	40	1256.40	73	4185.40
9	63.617	40 ½	1288.25	74	4300.85
9½	70.882	41	1320.25	75	4417.87
10	78.540	41½	1352.66	76	4536.47
10½	86.590	42	1385.44	77	4656.63
11	95.033	42½	1418.63	78	4778.37
11½	103.869	43	1452.20	79	4901.68
12	113.097	43½	1486.17	80	5026.56
12½	122.719	44	1520.53	81	5153.01
13	132.732	44½	1555.29	82	5281.03
13½	143.139	45	1590.43	83	5410.62
14	153.938	45½	1625.97	84	5541.78
14½	165.130	46	1661.90	85	5674.51
15	176.715	46½	1698.23	86	5808.82
15½	188.692	47	1734.94	87	5944.69
16	201.062	47½	1772.05	88	6082.14
16½	213.825	48	1809.56	89	6221.15
17	226.980	48½	1847.45	90	6361.64
17½	240.528	49	1885.74	91	6503.90
18	254.469	49½	1924.42	92	6647.63
18½	268.803	50	1963.50	93	6792.92
19	283.529	50½	2002.96	94	6939.79
19½	298.648	51	2042.82	95	7088.24
20	314.16	51½	2083.07	96	7238.25
20½	330.06	52	2123.72	97	7389.83
21	346.36	52½	2164.75	98	7542.98
21½	363.05	53	2206.18	99	7697.71
22	380.13	53½	2248.01	100	7854.00

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